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STUDIES REGARDING THE CULTIVATION OF OIL FLAX IN DOBROGEA IN THE CURRENT CLIMATIC CONTEXT

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Abstract. Oil flax has a special importance for the conditions in our country. This paper was inspired by the fact that over the past years, technical plants have been reconsidered in Romania, given the international crisis of resources and energy. Dobrogea is a favorable zone for oil flax and mixed flax. In the mixed flax, the technical length is between 30-50 cm, being used both for oil and the extraction of fibers. The major objectives of this paper are: aspects regarding the cultivation of oil flax and mixed flax in connection to distribution, biological particularities and requirements for climate and soil, with particular reference to the actual conditions of Dobrogea, as well as the cultivation technology of this plant which can be grown in drier regions as well. Given the climatic changes at international level, but also in our country, the structure of crops must be reconsidered, especially in the areas heavily affected by drought. Oil flax loves the heat and can be considered for cultivation on large surfaces in Dobrogea, on the condition that the cultivation technology should respect the climatic requirements.

Introduction

The particular importance of oil flax is given by the seeds which have high oil content (39-43%) and a high degree of siccativity (iodic index 168-192). Flax oil dries fast, is resistant to water and corrosive substances, which is why it is more used in the paint, varnish and enamel industry or as very good fixing substance for pigments in painting. Flax oil is also used in the alimentary and pharmaceutical industry, for the production of inks, soap, linoleum, in tannery, to impregnate electric insulators, etc. Due to the high content in protein substances (34.5-37.5% raw protein), the flax groats are used as forage for cows and pigs because they have calming and slightly laxative properties, which keeps the animals healthy. The stems resulted after harvesting the oil flax by combine (15-25 q/ha) can be bundled

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and used in the cellulose industry to make fine paper. If the technical length is over 45 cm, the plants are harvested by flax combine, obtaining 25-30 q/ha dry stems which can be used in the textile industry as flax fiber or in mixtures with synthetic fibers. The remaining chaff is used as feed for animals as it is highly nutritious and well digested. The tow resulted from the processing of the stems are used to obtain sound and thermal isolation plates, cellulose and fine paper. The resulting boon can also be exploited for the fabrication of plywood. Flax is also important because it leaves the field early and it is a good previous plant for other crops, especially autumn wheat.

1. Distribution

Oil flax is cultivated on all continents, between 36° southern latitude and 55° northern latitude. Lately, the surfaces cultivated with flax have been reduced as a result of the increase in productivity per ha. In 2008, approximately 2.43 million ha were cultivated with oil flax. The largest fields are in India, China, Canada and the USA.

Tab. 1. The cultivated surface and the average production of oil flax
In Romania, in the world and in Constanta county

Year	In the world		in Romania		In Constanta county	
	Cultivated surface -thousand ha-	Average production Kg/ha	Cultivated surface -thousand ha-		Cultivated surface -thousand ha-	Average production Kg/ha
1990	3939	741.6	49.9	562	8545	738.1
1991	3632	740.1	47.6	478	13383	538.4
1992	2972	748.6	25.8	693	6664	667
1993	3367	650.2	37.7	744	18317	803.8
1994	3356	731.7	11.0	585	6225	646.4
1995	3570	707.1	6.6	719	3898	738.3
1996	3209	771.9	7.3	618	1960	604.1
1997	3130	727.5	9.4	507	2923	682.5
1998	3287	834.1	2.7	1122	488	850.4
1999	3271	823.6	2.0	1373	80	200
2000	2706	761.4	1.3	738	49	286
2001	2618	726.8	1.2	1627	140	550
2002	2516	786.6	2.2	786	10	900
2003	2554	830.6	1.6	910	25	400
2004	2517	810.3	1.4	1752	-	
2005	2866	970.1	0.1	846	-	
2006	2851	893.0	0.29	1107	50	2000
2007	2256	848.9	0.47	833	112	348.2
2008	2436	902.6	0.3	706	50	800

*Statistical year book of Romania and FAOSTAT, 2008

2. Systematics. Biological particularities

Flax belongs to the Linaceae family, species *Linum usitatissimun* L. oil flax fits in the subspecies *transitorium* Ell. and *mediterraneum* Vav. et. Ell. The subspecies L.u. *transitorium* includes two forms in culture: proles meridionalis and proles anatolica. The flax types admitted into culture in our country are part of *Linum usitatissimum transitorium* proles *meridionalis*.

The vegetation period of oil flax cultivated in Romania is 85-110 days. The period between sowing and springing depends on soil temperature and humidity at the time of sowing. From springing to the small fir stage, there is a slow growing of the epigeous part, the plants being very sensitive to weeds, aphids and drought. In this interval, the roots grow intensely (its mass is 10-15 times bigger than the epigeous part). Oil flax has more developed roots than fiber flax, being adapted to drier conditions. Around blooming time, when it stops growing, the root system is reduced, compared to the epigeous mass, its power to dissolve and use the minerals in soil being diminished. In the small fir stage, the plants grow slowly (0.3-0.6 cm/day). This stage lasts from a height of 5-6 cm and 6-7 leaves to a height of 15-18 cm, when the plant has 14-15 leaves. The leaves are covered by a layer of wax, allowing the administration of most herbicides for oil flax. Between the small fir stage and the occurrence of buds-flowers, there is a period of intense growth (2-6 cm/day). At this stage, the plants absorb over 50-60% of the NPK and the necessary amount of water. The stem of oil flax is 40-70 cm tall and ramified, sometimes from the basis. The number of leaves on a flax plant is over 80-100, the foliar index being 4-5. The inflorescence is highly ramified, the number of ramifications reaching 40. Oil flax is facultatively autogamic, the proportion of cross pollination being influenced by soil, temperature and humidity. In higher temperatures and low humidity, the cross pollination percentage is higher.

The fruit is a capsule; the seed is flattened, oval-elongated, ended in the embryo zone with a rostrum. The seed of the oil flax is bigger than the seed of the fiber flax. In the oil flax, the mass of 1000 seeds (MMB) is 7-8.5 g, while in the Mediterranean flax, it is 9-13 g (compared to only 3-4 g in the fiber flax).

3. Relationships plant-vegetation factors. Ecological zones

Compared to fiber flax, oil flax is more demanding in terms of heat and less demanding in terms of humidity. The sum of the average temperatures over the vegetation period ($\sum t>0°C$) is 1800 - 2000°C. The minimum germination temperature is 1 - 3°C. In optimum conditions of temperature and humidity, seed germination lasts for three days. In the cotyledon stage, it is sensitive to low temperatures, but from this phase to the beginning of intense growth, flax can resist at temperatures of -4°C on the condition that the period is short. During the intense growing stage, flax needs average daily temperatures of 14 - 16°C at blossoming,

18 - 22°C during pollination-fecundation and over 20°C at maturity. The strong scorchers during maturity cause considerable production damages. When the temperature is high in excessively dry summers, there is a sudden maturation of the seeds, the accumulation of unsaturated fatty acids is impaired and thus oil quality is poor. In terms of humidity, during the entire vegetation period it requires 150-180 mm precipitations, uniformly distributed (optimum distribution on vegetation stages: springing- small fir 40-45 mm; small fir-blossoming 80-90 mm; blossoming-maturity 40-45 mm). If during the small fir-blossoming period, the water supply is poor, the growth, ramification and seed and oil production are diminished. After sowing, excessive humidity affects seed germination and the percentage of plants occurred, directly by lack of oxygen and indirectly by the formation of crust. Abundant precipitations during blossoming prevent pollination and fecundation, with negative consequences on productivity. Proper soil humidity and intense, lasting light (8-10 hours/day) favor the reduction of the height and the increase of plant ramification.

In terms of soil, flax prefers profound, fertile soils with medium texture, and well supplied with water. In regards to pH, flax prefers slightly acid or neuter soils (pH 6-7).

In Dobrogea, the very favorable zone stretches in the south-east part. This area is characterized by a well distributed pluviometric regime of 200 mm during the vegetation period, and by fertile soils with physical features proper to the development of oil flax. In Romania, the forest steppe zone provides the best vegetation conditions for the accumulation of unsaturated fatty acids for the production of oil with high degree of siccativity. This species brings an improvement of the crop structure in this area, creating thus better conditions for the place of wheat in the rotation.

4. Cultivation technology

Crop rotation. The best previous plants for the cultivation of oil flax are the autumn cereals, maize fertilized with manure and not sprayed with triazine herbicides, as well as annual legumes. Sunflower and beetroot are considered poorer previous plants because of certain common diseases (*Botrytis*) and of high potassium consumption. Potato can be a good previous plant for oil flax, if it was not attacked by *Rhizoctonia* and *Botrytis*. After sugar beet, the soil may lack boron. The following are not indicated as previous plants: sorghum, oat, hemp and cruciferous vegetables. Flax does not like monoculture. The repeated cultivation of flax on the same field causes the phenomenon of “soil exhaustion” and favors the attack of antracnosis, septoriosis, blight and especially fusariosis. This is why it is recommended that flax should only be cultivated on the same field after 5-6 years. Taking into account the short vegetation period, oil flax in placed on the field

cultivated next with autumn wheat (it is an excellent previous plant). It is also a good previous plant for all the spring crops.

Fertilization. Flax is demanding in terms of fertilization, as it has a short vegetation period, diminished roots with low power to dissolve and absorb nutritive elements, slow-growing intervals alternate with intense-growing intervals. Over 50% of the necessary NPK is accumulated in a short period of time (approx. 30 days), right before the end of blossoming. Oil flax needs important amounts of nutritive substances. For a production of 100 kg of seeds and the corresponding secondary production, oil flax extracts form the soil 5 - 7 kg N; 1.8 – 2.5 kg P_2O_5 and 3.2 – 5.5 kg K_2O (D. and Velicica Davidescu). The reaction to mineral fertilizers is determined by the soil supply with nitrogen, phosphorus and potassium, the optimum nitrogen doses being between 30 and 100 kg/ha, while the phosphorus and potassium ones being between 30 and 90 kg/ha. The nitrogen doses depend on the previous plant, on its fertilization or non-fertilization with manure, but also on the soil supply of water at sowing time. The unilateral fertilization with nitrogen, or the excess of nitrogen diminishes the plants resistance to falling and diseases, prolongs vegetation, reduces the oil content of seeds and influences negatively its quality. Phosphorus helps with the transformation of sugars into lipids, having thus a special importance in oil synthesis. The insufficiency of phosphorus leads to small leaves with reduced surface and improper blossoming and fruit production. This affects the final productivity. The N : P : K ratio is 1:1.5:0. If the previous plant consumes potassium, then the ratio is 1 : 1.5 : 0.5.

Nitrogen fertilizers are administered in spring and are incorporated into the soil with the special tillage for the preparation of the germination bed. The phosphorus and potassium fertilizers are incorporated into the soil with the autumn tillage. Boron has a particular importance for oil flax. If this element is insufficient, the seed production is reduced due to the “abortion” of flowers. Bacteriosis occurs on soils rich in calcium, under boron influence, this element being favorable for the development of root as well. Manure is not applied directly on the oil flax crop, but on the previous plant. Due to its short vegetation period, oil flax does not exploit manure very well. Moreover, this favors the development of weeds, prolongs vegetation and influences negatively the uniformity of ripening (determines late shooting).

Soil tillage. Flax is very demanding in regards to soil tilling. The slow growing rhythm in the first vegetation stages and poor soil shading (due to reduced leaves) are but a few special features that favor the growth of weeds. In the oil flax, 20 cm tilling is recommended, as this crop does not exploit greater depths. If it is necessary to incorporate the vegetable remains left after maize, sunflower, potato and beet, then it is recommended to plough deeper (25-30 cm). Soil leveling has a

particular importance, before or after the basic tillage. Also, the plough-land needs maintenance by repeated harrowing for the cutting and elimination of weeds till autumn. In spring, the field is prepared for sowing by combinator; the soil must be well broken up but not "pulverized," because if forms a curst, which is bad for springing.

Seed and sowing. The flax seed must come from the harvest of the previous year, separated from parasite plants, with minimum 99% purity, a germinative capacity of minimum 90%, germinative energy above 85% and MMB specific to the kind. Before sowing, the seeds must be treated with substances that protect the crop against aphids and diseases.

Sowing period. Oil flax is sown early in spring, when the soil temperature at 5 cm is 4 - 5°C. This ensures the efficient exploitation of soil humidity, the uniformity of springing, growing, ramification and maturation, increased resistance to aphid attack and drought. The experiences demonstrated that delayed sowing reduces production, shortens the seed formation and maturation period, which leads to the diminished accumulation of unsaturated fatty acids and diminished siccativity degree. The density of the field is very important for the growth and ramification of plants. A higher density means that the plants form a low number of ramifications and a low number of flowers, capsules and seeds. The highest productions are obtained at 800 - 900 germinative seeds/m^2. For mixed flax, the density must be 1500 germinative seeds/m^2. The seed quantity is 60 - 70 kg/ha for oil flax and 90 - 110 kg/ha l for mixed flax, depending on the useful value and on MMB. The distance between rows is 12.5 cm. the sowing depth in oil flax is 3-4 cm in light soils and in drought conditions, and 2-3 cm in heavier or wet soils.

Maintenance works. The most important maintenance works are: weed, pests and disease control.

Weed control. During the first 30 days, oil flax is very sensitive to weeds. Weed control can be accomplished by direct measures, namely, rotation, soil tillage, but also by indirect measures (specific herbicides).

Pests control. The most dangerous flax pests are *Aphtona euphorbiae* (flax flea beetle) and *Trips linarius* (thrips). Among the phyto-technical measures to reduce damages are the following: the use of seeds with high germinative energy (for uniform springing); optimum springing conditions by preparing the germinative bed very well; early sowing, so that the plants should become vigorous adults (they should overcome the cotyledon phase); treatment of the seeds with specific products. Flax thrips attacks the leaves and ramifications. Two-three warning treatments are done for the crop protection.

Irrigation. Depending on the precipitation regime, 1400 -1500 m^3 are administered per ha, fractioned into 2-3 watering sessions. It should be taken into account that the highest water consumption occurs during the intense growing

phase, the blossoming and seed filling.

Harvesting. Oil flax is harvested at full maturity, a stage characterized by the nearly total lack of leaves on the stem. 80-90% of the capsules are brown and the seeds have the color specific to the type. Delayed harvesting leads to capsule losses because the stems break, or the capsules fall from the inflorescence or they simply burst. The harvest of oil flax is done by means of the cereal combine, fitted with a smooth knife and regulated accordingly. If the stems are exploited as well (useful length over 45 cm), then the harvest is done by pulling, either manually, if the weather is dry, or mechanically (TLZ(V)-4 machine or LK(V)-4T machine), at the end of ripening in yellow (50% of the capsules are brown). The seeds are immediately threshed and conditioned by aeration and selection in order to reduce humidity under 11%.

Conclusions

Oil flax and mixed flax are good for cultivation in dry zones. Dobrogea offers favorable conditions for this plant. Oil flax is very sensitive to weeds in the first 30 days. Given the climatic changes at international level, but also in our country, the structure of crops must be reconsidered, especially in the areas heavily affected by drought. Oil flax loves the heat and can be considered for cultivation on large surfaces in Dobrogea, on the condition that the cultivation technology should respect the climatic requirements.

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