

ASPECTS REGARDING THE LINSEED OIL CULTURE IN ROMANIA IN THE CONTEXT OF THE ONGOING CLIMATE CHANGE

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Abstract. Nowadays, at global level, the linseed oil culture is more important economically than the linseed cultures for fiber. The world's largest linseed production is the linseed oil, followed by the culture for the consumption of seeds and for fibers. In this context, this study presents the evolution and the main trends in the production of the linseed oil for Romania in the period 2008-2017, the analysis being based on the values of specific indicators, namely the areas cultivated with linseeds and the production of the linseed oil achieved at the national level, macro-regions and development regions, both as a total and in the private sector as well. This analysis will be done in the context of the ongoing climate change also affecting Romania's territory. Analysing the results, one can notice that, although after 1990 the cultivated areas have decreased dramatically, since the integration of Romania into the EU, the linseed oil cultivated areas have started to grow. Thus, in 2017, Romania was the sixth EU linseed oil producer in the EU, with the South-East region holding a significant share of the cultivated areas.

Introduction

Known as an herbaceous plant, the linseed (*Linum usitatissimum*) with blue flowers is an annual old crop, lately preferred by agriculture for both its protein properties, as well as for its products – seeds, oil, fibers produced from its strain. The linseed culture is an alternative to the rape and sunflower crops. Nowadays, Romania is an area with very good conditions for cultivating protein plants. This conclusion was also reached by the experts from the EU member states, which participated, in 2018, at the workshop “*The Vegetable Proteins – Agronomic Practices and Environmental Benefits*” organized by the Ministry of Agriculture

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and Rural Development (MARD) at the proposal of the General Directorate for Agriculture and Rural Development of the European Commission (MARD, 2018).

Over time, the linseed oil varieties have been developed, being plants shorter than the varieties for fiber, but with a rich branch in order to have a larger number of flowers on the stem because the seeds contain 40 to 45% oil (Munteanu et al., 2008). The linseed oil has a high content of linoleic acid, of 22-70% (Marin and Constantinescu, 2011). After 1990, varieties with weak linoleic acid have also appeared. Due to the properties of the linoleic acid which oxidizes easily and is a quick reagent, these varieties of linseed oil had mainly an industrial use, being turned into a quick-drying oil used for paints, lacquers, varnishes, printing inks, soap etc. The fibers resulting from the linseed cultures are used both in the paper production and for increasing the resistance of the recycled paper. In the car and aerospace industries, the linseed for fiber replaces the glass fiber because it is easier to be obtained, it has a lower weight and is biodegradable. In addition, in the human diet, the seeds are the richest natural source of linoleic acid, a fat Omega-6 oil, which the human body doesn't produce. The medical studies indicate that the linseeds used in human alimentation, have a role in reducing the risk of the heart diseases, of treating bronchitis, the intestinal pain etc.

The linseed oil is a heat-loving plant, requiring a moderate humidity and with a wide latitude spread, between 66° North and 36° South latitudes (Tabără, 2005).

At global level, the largest areas cultivated with linseed oil are found in Asia, followed by the North America, Europe, Africa and the South America (Marin and Constantinescu, 2011). The most important linseed oil cultivators, according to Food and Agriculture Organization of the United Nations (FAO) are India, China, Russia, Canada, Argentina, USA, Ethiopia etc. (FAO, 2018).

In Romania, the linseed oil has held the second place among the oil plants after the sunflower until 1989. Since 1990, the cultivated areas with linseed oil have started to decrease until 2007, the year of Romania's integration into the European Union (EU), when they started to grow again. The most favorable areas are: the West of the Banat province, the Center and the South of Oltenia, the Southern Muntenia, the South-Eastern Dobrogea, being considered that in Romania the extra-Carpathian regions are favorable to this culture. For the entire vegetation period (March-August) of the linseed oil, the sum of the daily average air temperature is 1600-1800°C, and the required amount of precipitation is 150 mm (Doucet and Doucet, 1964). The most suitable soils are the chernozem and the brown-red soils (Marin and Constantinescu, 2011).

In Romania, according to the statistics provided by the "*The Linseed Oil and Linseed for Fiber Improvement Program*" within the National Institute of Agricultural Research and Development from Fundulea, several varieties of linseed oil are grown, varieties obtained by diversifying the genetic basis of this species.

Thus, 26 varieties were created during the entire breeding program, which had a well-defined role, namely to ensure the genetic advancement in order to boost the production and to positively influence the stability and quality of the crops. The most important are: *Geria* (1991), *Raluca*, *Gențiana* (1993), *Iulia* (1994), *Floriana* (1998), *Lirina* (1998, chestnut-coloured seed breeding), *Olin*, *Oliana* (1998), *Alexin* (1999), *Florinda* (1999), *Janina* (1999), *Iunia 96* (2000), *Fluin* (2000), *Cristina* (2003) etc. (Doucet and Doucet, 2007).

Methodology

In order to highlight the trends in the evolution of the linseed oil culture in Romania, in the context of the ongoing climate change, the space and time variability of the factors and indicators specific to the linseed oil culture have been analysed, both for Romania and on macro-regions and development regions. Several regional statistical indicators will be analysed, such as: the areas and the total linseed oil production in correlation with the property forms. These data are analysed for the periods 1990-2005 and 2008-2017 and are provided by the National Statistics Institute (NSI), the European Commission for Agriculture and Rural Development and the Food and Agriculture Organization of the United Nations (FAO). The climate changes observed in the thermic conditions and precipitation regime are highlighted by the climate data of the monthly and annual temperature and precipitation provided by the National Administration of Meteorology (NAM) for the periods 1981-2010 and 1900-2017 and by the specialised literature. Methods of statistical processing and graphic and cartographic representations have been used, offered by the Open Source GIS and Microsoft Office. The simple regression technique has also been used in order to notice the trends for the cultivated areas and the production of the linseed oil.

Results and discussions

In Romania, the annual average air temperature increased in the last hundred years by 0.6°C (Mateescu, 2016). This tendency to increase the annual thermic regime was found especially after 1991, the warmest year being 2015, with a positive deviation of 1.7°C compared to 1901-2017 (NMA, 2018). As for the annual amount of rainfall presents a much more complicated trend over Romania (Prăvălie et al., 2018; Croitoru et al., 2018). The annual amount of rainfall varies from 300-400 mm in the Southeast to over 1200 mm in the Carpathians (NMA, 2018).

After 1991, an increased frequency and intensity of dryness and drought phenomena has been noticed (Mateescu, 2016). For the period 1981-2010, considered as the reference or normal climatic period, the annual thermic and

precipitation regime is shown in Figure 1. There has been assumed that the Extra-Carpathian areas best meet the bio-climatic requirements of the linseed oil. In Figure 2, we can notice the increasing tendency of the annual air temperature in Romania, calculated for 29 meteorological stations with long-term data records (about 100 years), for the period 1901-2017. In the latest Intergovernmental Panel on Climate Change (IPCC) report, in 2018, the Central and Southern Europe is located in the area where the risks of 2°C global warming are particularly high (IPCC, 2018).

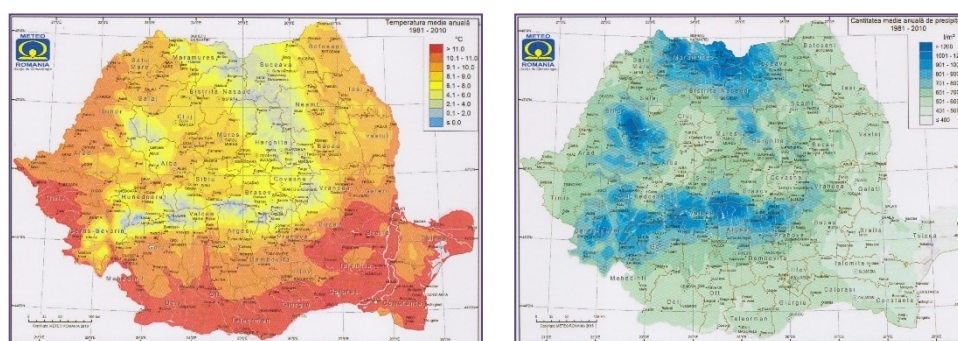


Fig. 1. The annual air temperature (left) and the annual precipitation regime (right) in Romania, for the period 1981-2010
Source: NMA, 2018

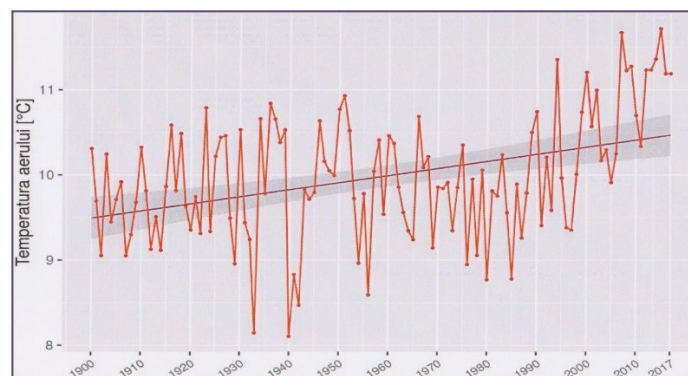


Fig. 2. The annual average air temperature in Romania, calculated for 29 meteorological stations, for the period 1901-2017 Source: NMA, 2018

There is a complex correlation and a system of obvious relationships between the climatic conditions and the agricultural crops. Knowing these, there is the possibility of improving the agricultural management and adapting to the climate

changes. In the context of the ongoing climate change, presented above, we will analyze several indicators of regional statistics for the linseed oil cultures.

By analysing the data in table 1, which represents the situation of the linseed oil cultures in Romania in the 1990s, it can be noticed that the area cultivated in 1990 was of 49,874 ha, the largest share being held by the Macro-region 2 - 58.6% (29,207 ha), the greatest contribution being made by the South-Eastern Development Region - 94.7% (27,648 ha). In 15 years, the cultivated area with linseed reached 80 ha (2005). If in 1990 the linseed oil was not cultivated in the private sector, in 2005, more than half of the cultivated area (60 ha) belonged to the private sector, and the largest share was held by the Macro-region 3 - 75% (50 ha). Since 2000 the private sector contains: the private property of the state, of the administrative-territorial units, of the legal and natural persons (NSI, 2019).

Analysing the statistics in table 2, for the period 2008-2017, one can see an increase of the area cultivated with linseed oil, both for the private sector, as well as for the whole country. We use the both categories of propriety to highlight the evolution in time of the areas cultivated with linseed oil on property forms. This also reflects the interest for linseed oil culture.

The largest cultivated area – 3,042 ha was registered in 2014, while the lowest – 313 ha was registered in 2009. In the private sector, the situation shows a significant increase of the cultivated area comparing to the state sector (with the exception of the years 2008 - 46 ha, 2012 - 10 ha, 2015 - 8 ha, 2016 - 26 ha and 2016 - 60 ha). The integration of Romania into the EU has meant, for this agricultural sector, the growth of the cultivated areas, both for the general total and the private sector. But even though the cultivated areas have grown, the values from 1990 have not been reached.

Analyzing the evolution of the areas cultivated with linseed oil for macro-regions in the period 2008-2017, one can observe that: the Macro-region 1, registered the lowest areas, and in the years 2009, 2012, 2013 and 2017, there were no areas cultivated with linseed oil; in the Bucharest-Ilfov region, nothing has been cultivated since 2009, because the agricultural land in this area has received other destinations; the Macro-region 2, includes the largest areas cultivated with linseed oil, with the exception of 2011 - 440 ha; in the Macro-region 3, there is a significant increase of the cultivated areas, for example, in 2011, it ranked first with 887 hectares cultivated, and in the South-Muntenia region, the private sector is in full process of growth, being in 2008 - 14 ha and in 2017 - 461 ha. In 2017, with an area of 1.92 thousand hectares cultivated with linseed oil, Romania occupies the sixth position in the EU producers ranking (Table 2, Figure 3).

The total area cultivated in the EU in 2017 with linseed oil has increased to 81.49 thousand ha, although the cultivators have, no longer, specific support measures for oilseeds (European Commission, 2018). In 2017, the following

situations are found for the areas cultivated with linseed oil as compared to Romania's totals: the first place is held by the Macro-region 2, having a percentage of 56% (1073 ha), the South-East Development Region having recorded the highest cultivated areas, 94% (1007 ha); the Macro-region 3 recorded 521 ha cultivated (27%) and the Macro-region 4 registered 328 ha cultivated (17%).

Tab. 1. The areas (thousand ha) cultivated (in green) with linseed oil, for the period 1990-2005 a - total per country, b - private sector

Sector type	Year			
	1990	1995	2000	2005
MACRO-REGION 1 - M1				
NORTH – WEST Region - 1				
Romania	1,104	18	-	15
private sector	-	18	-	15
CENTER Region - 2				
Romania	-	-	-	-
private sector	-	-	-	-
MACRO-REGION 2 – M2				
NORTH-EAST Region - 3				
Romania	1,559	52	-	15
private sector	-	31	-	15
SOUTH-EAST Region - 4				
Romania	27,648	5,176	174	-
private sector	-	3,144	35	-
MACRO-REGION 3 – M3				
SOUTH-MUNTENIA Region- 5				
Romania	11,228	671	1,024	50
private sector	-	581	119	30
BUCHAREST– ILFOV Region - 6				
Romania	-	-	-	-
private sector	-	-	-	-
MACRO-REGION 4– M4				
OLTENIA SOUTH-WEST Region - 7				
Romania	4,089	547	139	-
private sector	-	-	-	-
WEST Region - 8				
Romania	4,246	130	10	-
private sector	-	-	-	-
(A) GENERAL TOTAL				
	1990	1995	2000	2005
	GENERAL total Romania			
	49,874	6,594	1,347	80
	Total private sector			
	-	3,774	154	60

1990

1995

2000

2005

Source: processed after NSI, Tempo AGR 108A, www.insse.ro, accessed on 29.03.2018

As for the linseed oil production, in 1990, there were registered 28040 tons, while in 2005, there were registered 55 tons, of which 33 tons in the private sector.

Tab. 2. The areas (thousand ha) cultivated with linseed oil during 2008-2017

Sector type	Year										2017/ 2008 %
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	
(B) MACRO-REGION 1 - M1											
NORTH – WEST Region - 1											
Romania	96	-	9	34	-	-	-	-	-	-	-
private sector	96	-	9	34	-	-	-	-	-	-	-
(C) CENTER REGION - 2											
Romania	-	-	-	-	-	-	2	65	16	-	-
private sector	-	-	-	-	-	-	2	65	16	-	-
(D) MACRO-REGION 2 - M2											
NORTH-EAST Region - 3											
Romania	-	1	-	5	30	9	207	17	26	66	-
private sector	-	1	-	5	30	9	207	17	26	66	-
(E) SOUTH-EAST REGION - 4											
Romania	257	51	529	1,338	410	1,956	2,215	1,052	1,361	1,007	392
private sector	257	51	529	1,338	410	1,956	2,215	1,052	1,361	1,007	392
(F) MACRO-REGION 3 - M3											
SOUTH-MUNTENIA Region - 5											
Romania	44	9	210	73	887	873	342	414	614	521	1,184
private sector	14	9	210	73	887	873	342	406	588	461	3,293
(G) BUCHAREST– ILFOV REGION - 6											
Romania	16	-	-	-	-	-	-	-	-	-	-
private sector	-	-	-	-	-	-	-	-	-	-	-
(H) MACRO-REGION 4 - M4											
OLTENIA SOUTH-WEST Region - 7											
Romania	-	252	-	120	10	-	75	77	143	20	-
private sector	-	252	-	120	-	-	75	77	143	20	-
(I) WEST REGION - 8											
Romania	80	-	90	48	115	115	201	16	19	308	385
private sector	80	-	90	48	115	115	201	16	19	308	385
General total Romania	493	313	838	1,618	1,452	2,953	3,042	1,641	2,179	1,922	390
Total private sector	447	313	838	1,618	1,442	2,953	3,042	1,633	2,153	1,862	417
Source: processed after NSI, Tempo AGR 108A, www.insse.ro , accessed on 29.03.2018											

Source: processed after NSI, Tempo AGR 108A, www.insse.ro, accessed on 29.03.2018

By analysing the evolution of the linseed oil production in Romania, overall, in the period 2008-2017, the lowest value of production was recorded in 2009, of 221 tons, and the highest in 2014, of 4046 tons (Table 3). If referring these minimum and maximum production values to the corresponding cultivated areas, one can notice that they correspond to the smallest cultivated area, registered in 2009, while the largest one was cultivated in 2014.

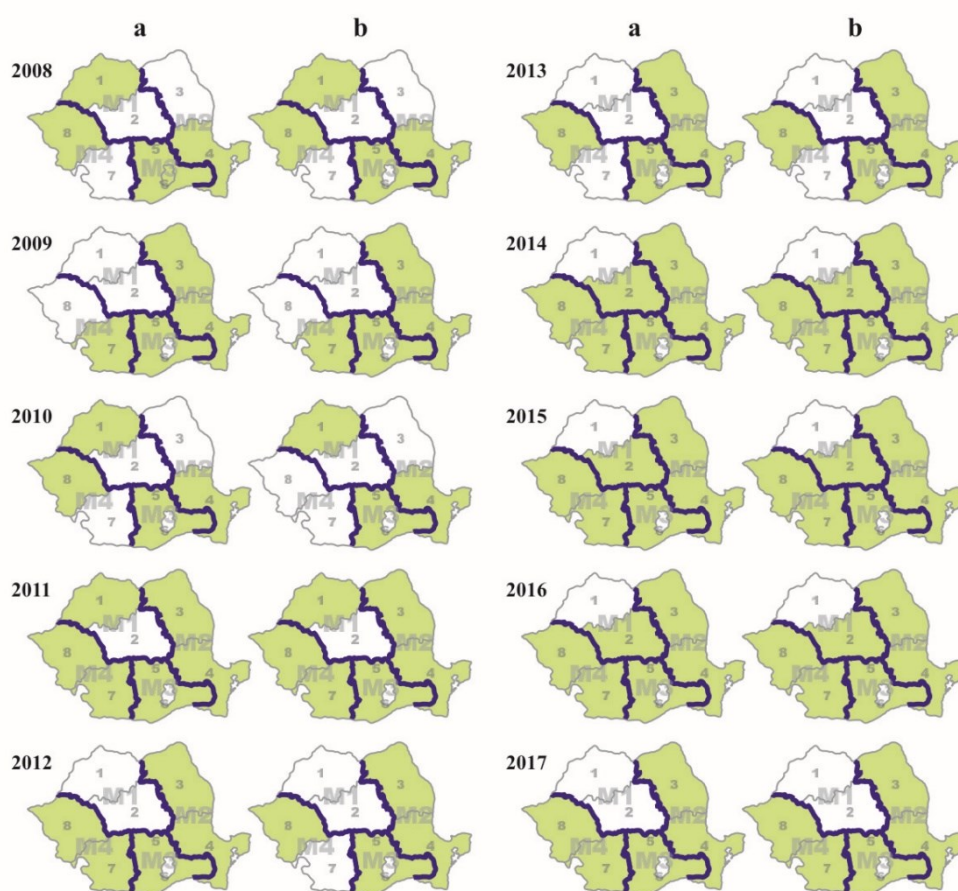


Fig. 3. The areas (thousand ha) cultivated (in green) with linseed oil during 2008-2017
a - total production Romania, b - private sector

The analysis of the data presented in tables 3 and figure 4 shows that the largest linseed oil production is obtained in the private sector, in the Macro-region 2, with the exception of the year 2012, when the highest production value was recorded in the Macro-region 3 (1893 tons in the private sector).

The year 2014 was the year with the highest crop: 2,986 tons in the Macro-Region 2, in the private sector as a result of the biggest cultivated area with linseed oil. By analysing the evolution of the linseed oil production on the Development Macro-regions, in the period 2008-2017, one can observe that the Macro-region 1, registered the lowest productions. In the Bucharest-Ilfov region, no linseed oil production has been obtained since 2009.

Tab. 3. The linseed oil production (tons) in Romania, in the period 2008-2017

Sector type	Year										2017/ 2008%
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	
(J) MACRO-REGION 1 - M1											
NORTH – WEST Region - 1											
Romania	48	-	7	21	-	-	-	-	-	-	-
private sector	48	-	7	21	-	-	-	-	-	-	-
(K) CENTER REGION - 2											
Romania	-	-	-	-	-	-	2	94	28	-	-
private sector	-	-	-	-	-	-	2	94	28	-	-
(L) MACRO-REGION 2 – M2											
NORTH-EAST Region - 3											
Romania	-	2	-	8	46	9	478	25	33	45	-
private sector	-	2	-	8	46	9	478	25	33	45	-
(M) SOUTH-EAST REGION - 4											
Romania	311	41	672	1,479	477	2,001	2,508	1,629	2,234	1,662	534
private sector	311	41	672	1,479	477	2,001	2,508	1,629	2,234	1,662	534
(N) MACRO-REGION 3 – M3											
SOUTH-MUNTENIA Region- 5											
Romania	4	12	249	43	1,893	1,447	487	673	1,156	880	22,000
private sector	3	12	249	43	1,893	1,447	487	672	1,132	803	26,767
(O) BUCHAREST– ILFOV REGION - 6											
Romania	16	-	-	-	-	-	-	-	-	-	-
private sector	-	-	-	-	-	-	-	-	-	-	-
(P) MACRO-REGION 4– M4											
OLTENIA SOUTH-WEST Region - 7											
Romania	-	166	-	237	8	-	134	141	164	62	-
private sector	-	166	-	237	-	-	134	141	164	62	-
(Q) WEST REGION - 8											
Romania	15	-	171	29	202	96	437	5	23	510	3,400
private sector	15	-	171	29	202	96	437	5	23	510	3,400
General total Romania	394	221	1,090	1,817	2,626	3,553	4,046	2,567	3,638	3,159	802
Total private sector	377	221	1,090	1,817	2,618	3,553	4,046	2,566	3,614	3,082	818
Source: processed after NSI, Tempo AGR 108A, www.insse.ro, accessed on 29.03.2018											

Source: processed after NSI, Tempo AGR 108A, www.insse.ro, accessed on 29.03.2018

The largest increase in production is recorded in the Macro-region 3, in the private sector of South-Muntenia region, where from 3 tons obtained in 2008, the production reached 803 tons in 2017. With a production of 3.16 thousand tons of linseed oil, Romania was the fifth EU producers ranking, in 2017 (although it is a linseed oil cultivator - the fifth position - Germany does not display any data on

production). The top places are occupied by the UK, with 48 thousand tons, France - 42.31 thousand tons and Sweden -16.8 thousand tonnes (European Commission, 2018). The total EU linseed oil production has reached 136.81 thousand tons in 2017, which meant about 2/3 of the EU demand. In 2017, more than 50% of Romania's linseed oil production was obtained in the Macro-region 2 - 54%. Of the 1,707 tons obtained in this Macro-region, 97% is obtained in the South-East Development Region (1662 tons) and 3% in the North-East Region (45 tons). The Macro-region 3 ranks the second, with 880 tons (28%) of the 3159 tons in the total linseed oil per country in general, while the Macro-region 4 represents 18%, meaning 572 tons (Figure 4).

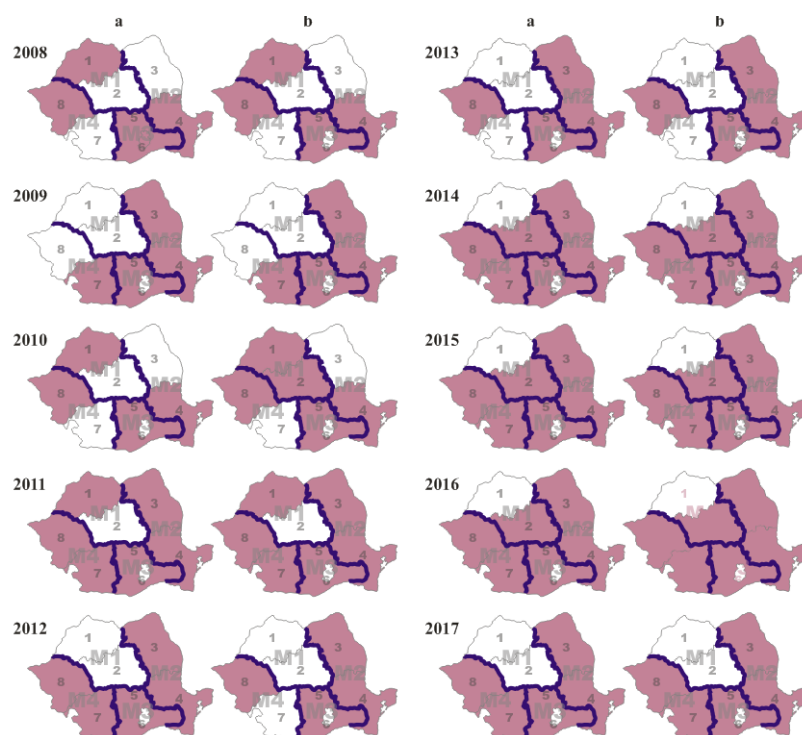


Fig. 4. The linseed oil production (in mauve) in Romania (tons), in the period 2008-2017, a - total production Romania, b - private sector

In figure 5, one can notice that there is a general increasing trend, both for the areas cultivated with linseed oil, registered as a general total in Romania, as well as for production. The smallest values were recorded in the period 2004-2008 from the entire analyzed period (2000-2018).

The increase of the linseed oil area and productivity after 2008 is a consequence of the economic interest of the farmers for this crop. It is a commercial crop that brings profit per hectare. The price of a ton of linseed oil seeds is equivalent to an average of eight tons of wheat per hectare or 12-13 tons of maize (Gazeta de Agricultură, 2019). Also, the linseed oil has many uses and is one of the most beautiful cultures, especially during the blooming, creating a special landscape.

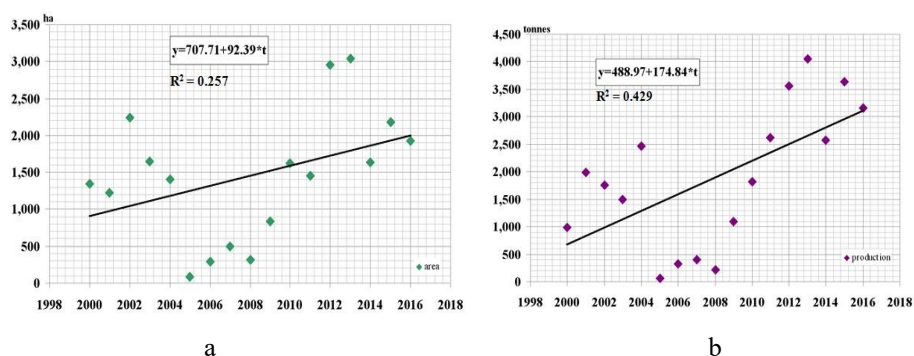


Fig. 5. The trends of surfaces (a) and productions (b) for the linseed oil in Romania

Conclusions

The critical period of water requirement for the linseed oil culture corresponds to the May-June interval, when the plants grow both in height and in terms of branches. In July-August, the high temperatures and low precipitations are needed in order to ensure the good agricultural yields. With a thermic requirement for the entire vegetation period (March-August) of 1,600-1,800°C and a 150 mm precipitation amount, the linseed oil culture can easily withstand the drought periods comparing with the linseed for fiber culture. Due to the changes observed in the agro-climatic conditions of Romania (increase of the average annual air temperature) and to the optimum temperature and precipitation limits (a small amount of water from precipitation specific to an excessively dry regime), during the vegetation period, the linseed oil has favorable conditions for cultivation in Romania.

Although it used to occupy large areas before 1990, this plant was reintroduced into the culture, especially after 2007, with a substantial increase in the area cultivated with linseed oil, both for the private sector and for the whole country. In 2017, Romania was the sixth cultivator and the fifth linseed oil producer in the European Union, and the South-East Development Region had the largest cultivated area and production. With

the growth of the cultivated areas, the production of linseed oil plant has increased. Also, from the spatial distribution of land and production, at country level, the linseed oil can find a degree of favourability for the extra-Carpathian regions.

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