Scientific Bulletin. Series F. Biotechnologies, Vol. XXIV, No. 2, 2020
ISSN 2285-1364, CD-ROM ISSN 2285-5521, ISSN Online 2285-1372, ISSN-L 2285-1364

LIFE CYCLE ASSESSMENT OF *CAMELINA SATIVA* CROP IN A CIRCULAR ECONOMY APPROACH - A MINIREVIEW

Andrei-Georgian PÎRVAN[1], Ștefana JURCOANE[2], Florentina MATEI[2]

[1]University of Agronomic Sciences and Vetrinary Medicine of Bucharest, Doctoral School - IMRVA, 59 Marasti Blvd, District 1, Bucharest, Romania
[2]University of Agronomic Sciences and Vetrinary Medicine of Bucharest, 59 Marasti Blvd, District 1, Bucharest, Romania

Corresponding author email: andrei_parvan94@yahoo.com

Abstract

Camelina (Camelina sativa) is a flower plant belonging to the family Brassicaceae, originating in Eastern Europe. Camelina oil has many applications in various fields such as cosmetics, pharmaceuticals, animal feed etc. The oil obtained from Camelina seeds has a high content of fatty acids with 50-60% unsaturated fatty acids, 35-40% omega 3-fatty acids and 15-20% omega 6-fatty acids. The main attractive features are: drought and frost tolerance, disease and pest resistance, a considerably high seed oil content, and satisfactory seed yields, in particular under low-input management and in limiting environments. The environmental benefits of the crop and a multipurpose applicability of the oil make Camelina sativa a promising oil-seed crop. Animal feeding has been identified to be a key factor in environmental sustainability. For this reason, by carrying out a life cycle assessment, there was many investigations focused on studying the environmental performance of the production of Camelina sativa in different regions of the world such as United States of America, Spain and France. For all of this utilities, Camelina sativa can be a part of circular economy in future.

***Key words**: antioxidants, camelina oil, fatty acids, lecithin, stability, tocopherol.*

INTRODUCTION

Camelina (*Camelina sativa* L. Crantz) has the popular names gold of pleasure and false flax. It is an annual member of the *Brassicaceae* family (Putnam et al., 1995; Zubr., 2003) from south-eastern Europe and south-western Asian steppe region (Zohary & Hopf, Eynck et al., 2013). *Camelina sativa* was grown as an agricultural crop before the Second World War in Russia and a few European countries. In Bronze Age in Western Europe and Scandinavia was found seeds and siliculas of *Camelina sativa* ssp. *C. linicola*. Camelina plants are annual or biennial herbs, the flowers are yellowish colored, hermaphroditic actinomorphic, grouped in racemes, leaves are simple, lanceolate to narrowly elliptic. Their seeds are formed in dehiscent siliques, pubescent annual (height: 3-80 cm). Leaves lanceolate, oblong or linear lanceolate (long: 20-70 mm, wide: 2-10 mm), pubescent, with sagitate or auricular base, with entire margins to subdenticulate, at the acute apex. Flowers with oblong seples (long: 2-3 mm), with obovate and yellow petals (long: 4-5 mm), grouped in terminal raceme.

It is a very good source of animal feed products and human food because *Camelina sativa* has essential fatty acids, particularly n-3 (omega-3) fatty acids (Waraich et al., 2013; Belayneh et al., 2018).

The oil obtained from camelina seeds has a high content of fatty acids with 50-60% unsaturated fatty acids, 35-40% omega 3-fatty acids and 15-20% omega 6-fatty acids. The main attractive features are: drought and frost tolerance, disease and pest resistance, a considerably high seed oil content (Belayneh et al., 2015).

CULTIVATION TECHNOLOGIES FOR *CAMELINA SATIVA*

In the context of drought becoming more and more aggressive in Romania, a less popular culture could be an opportunity for farmers, especially since this plant is not at all pretentious in terms of soil or weather conditions. *Camelina sativa* is the one known mainly because it is used as a raw material in obtaining the kerosene used by the airplanes.

To introduce the plant into the culture, the most important elements of the culture of camelina are: analysis of the composition chemicals of seeds camelina and evaluation profile of fatty acids from chamomile oil by highlighting high content polyunsaturated fatty acids Omega-3 type (Dobre et al., 2014; Toncea et al., 2013, Feussner, 2015), economic efficiency of camelina culture given by reduced costs setting up and maintenance, the possibility to use new practices agricultural for camelina culture, carrying out works minimum soil, organic farming, introduction as double culture (Dobre et al., 2014; Berti et al., 2016).

Camelina has low demands on soil and climate so can be grown on `marginal` soils, but for high yields it is recommended a soil with medium fertility and no weeds. Camelina can be grown without problems on damaged or contaminated soils. Established on barren land, impracticable or even contaminated "it cures" the soil, the plant fertilizes the substrate and prepares it for more demanding crops.

For the sowing of the camelina, it is necessary an advanced ground cutting because the camel seeds are very small. The operations performed before sowing are plowing, debating and rolling. The plowing is done at a depth of 20-23 cm, but the grounding and leveling must be done very well (with the combiner), precisely to avoid the spread of seeds. The experiments carried out in the research institutes in Romania (Dobre et al., 2014) have shown that there is not necessarily a need for a plow, as there are sufficient minimum interventions of double discussion and roll-over. In camelina culture, the vegetation period is very short, somewhere at 3 months and does not require any further maintenance of plants and soil until harvest.

The culture is set up in autumn or spring because the short period of camelina vegetation and its resistance to drought and frost allow the establishment of the crop in both autumn and spring, which recommends it for both rotational and double culture.

The best cultivation technologies with low input energy technology for *Camelina sativa* in Romania is to cultivate as a second crop, after the main crop represented by triticale. Minimal tilling system was used to reduce energy consumption. Originating from Austria, ‘Calena’ was tested, without fertilizers and water and the climatic conditions were monitored (precipitation and temperature). In conclusion, *Camelina sativa* can be cultivated in Romania as a double crop but is very important to sowing the plant in the late June - early July and after camelina sowing, watering is necessary to stimulate plant emergence (Dobre et al., 2014).

The sowing must be done at least 3-4 weeks prior to the sowing date of this trial: fertilizer application is needed in order to increase camelina yield, watering is mandatory after camelina sowing in order to stimulate plant emergence.

VALORISATION OF *CAMELINA SATIVA*

Camelina is grown for its seeds containing sicativa oil, with the iodine index Ii = 144-155. Oil extracted from camelina seeds is clear, golden and can have multiple uses: from the manufacture of paints and varnishes, to obtaining biopolymers and bioplastics, adhesives, in the pharmaceutical (antioxidant), cosmetic (massage oils, natural cosmetics and aromatherapy products), soaps (potassium soap), or as biofuel for agricultural machines equipped with diesel engines.

The productivity of camelina crop varies depending on the time of sowing, the use or not of fertilizers, soil quality, irrigation or not of the soil, the correct use of herbicides. Depending on these factors the productivity of spring or autumn crops is between 800-2,300 kg/ha. In the case of double crops, the productivity per hectare on irrigated land is 1,100-1,200 kg/ha, while the double crop on non-irrigated land brings a production of 500-800 kg/ha.

The possible industrial applications of camelina include its use in environmentally safe paintings, coatings, cosmetics and low emission biodiesel fuels (Bonjean and Goffic, 1999; Bernardo et al., 2003). Although the presence of polyunsaturated fatty acids make camelina oil susceptible to lipid oxidation but it remains sufficiently stable during storage due to the presence of antioxidants in the seed (Ni Eidhin et al., 2006; Abramovic et al., 2007).

The nutritional deficiency due to the disproportion of poly-unsaturated fatty acids can be alleviated by the addition of n-3 fatty acid rich oils in the diet. In such a situation camelina oil can be an excellent source of poly-unsaturated fatty acids and n-3 fatty acid in particular. Camelina oil can enhance the biological value of diet by changing the proportion of n-6/n-3 fatty acids (Petre et al., 2015).

Animal feed

Camelina oil cake or meal can be used as a protein rich source in poultry diets (Zubr, 1997). Camelina oil mixed with chicken (*Gallus gallus domesticus*) feed increased the n-3 (omega-3) content in the eggs without any unpleasant flavor, which often comes when flax oil is used (Rokka et al., 2002).

In Finland, the meal was used in the feed of broiler chickens and it was concluded that the high glucosinolate content of Camelina meal was not suitable for broiler feeding (Waraich et al., 2013).

Medicinal value

Because of its beneficial health effects (Ni Eidhin et al., 2003), camelina oil possesses great potential if is used in the production of health promoting supplements. Karvonen et al. (2002) determined cholesterol reducing effect of camelina oil in a test with mildly and moderately hypercholesterolemic subjects.

To obtain the oil, the camelina seeds are cold pressed, and the machine used may be the one used in the case of rapeseed. A small capacity seed press that can process 3 kilograms of seed per hour costs around 2,000 euros.

Camelina oil can be used as a biofuel. The seeds of camelina are very small, half a kilogram contains about 400,000 seeds. The oil content of a seed is 35-38%, which makes them more efficient than soybeans, which contain about 20% oil. In Camelina oil, 55-56% omega 6 fatty acids predominate and 11-12% omega 3 fatty acids predominate (Waraich et al., 2013).

Biodiesel/fuel production

Biodiesel, a low cost renewable fuel made from vegetable oils or animal fat, has recently attracted great attention as one of the more important alternatives for petro-diesel fuel. Biodegradability, lower sulfur and aromatic content, derivation from renewable and waste feedstock, higher cetane number and less emission of carbon monoxide are the main advantages of biodiesel.

Cameline oil can replace diesel with a simple adaptation made according to the scheme of the engineer Paul Dobre from the Mechanization Department of USAMV Bucharest, tractors and diesel engines used in agriculture and not only can be supplied with cameline oil (Dobre et al., 2014).

The simplicity of the works and the low costs of cultivation combined with the increased productivity per hectare and with the many questions of the seeds make *Camelina sativa* an excellent solution both for farmers who want to substantially reduce their fuel costs for agricultural work, and for those who will to diversify their cultures (Moraru et. al., 2013).

LIFE CYCLE ASSESSMENT - STUDY CASES FOR *CAMELINA SATIVA* IN DIFFERENT REGIONS

Life Cycle Assessment (LCA) is a technique used to assess the environmental impacts of a product during its entire life cycle from the “cradle”, where raw materials are cultivated, and their products with final application or can be related only to agricultural technology and possibility of using its by products in sustainable application such as animal nutrition in commercial farms (Petre et al., 2013).

The evaluation of the life cycle of a product can also be used to compare two different production processes in terms of use of resources and emissions. As defined by ISO standards and several studies, a correct LCA assessment consists of four major phases, (ISO14040): 1) Goal and Scope Definition; 2) Inventory analysis; 3) Impact assessment; 4) Interpretation.

To demonstrate the effect of reducing greenhouse gases different authors (Krohn & Fripp, 2012; Petre et al., 2015) have evaluated the life cycle of carbon in the production of biofuel using *Camelina sativa* as a raw material and its social implications in the context of meeting the sustainability criteria.

During the agricultural production process, to demonstrate the importance of reducing the environmental burdens, for the highest environmental performance, camelina oil was used as a feedstock for fuel production.

Attaining higher seed yield would dramatically lower environmental impacts associated with camelina seed, oil, and fuel production. The lower GHG emissions and energy consumption associated with Camelina in comparison with other oilseed derived fuel and petroleum fuel make camelina derived fuel from Canadian Prairies environmentally attractive (Li et al., 2014).

In Romania, camelina meal is very good to be fed as a protein source because feeds and forages are common to be produced by each farm in order not to buy compound feed from feed mills. Camelina cake or camelina meal resulted as a 60-70% from crops crushed, chemical analysis and trials performed worldwide suggest that can be fed to poultry, swine and ruminants. Camelina meal can replace up to 15% of the protein sources from the standard diet of dairy cows, trial for assessing nutritional benefits will start after 2015 harvest will be crushed, results will follow to complete our study. Nutritional profile is favourable for using in daily ratio and safely replace important amount of protein sources in cow's ratio, as an alternative to seasonal prices of the protein sources (Petre et al., 2015).

CIRCULAR BIOECONOMY - PRINCIPLES AND LINK TO ENVIRONMENTAL PROTECTION

In the European Union, circular bioeconomy is very important, accounting for 9 percent of Europe's economy. A circular bioeconomy is an economic system aimed at eliminating waste and the continual use of resources.

Within the environment protection, the total flow of biomass is 25 percent higher compared to the total flows of the last years. The circular bioeconomy is more present compared to the last years (Ronzon et al., 2017). Biomass found in the European Union comes from 63% of agriculture, 36% of forestry and 1% of fishing (Gurria et al., 2017).

Biofuel production is directly proportional to agricultural biomass, using only 2% of it (Gurria et al., 2017).

A principle addressed in the circular economy is related to the transition to unconventional energy systems in Europe. For an extension of the application of renewable energies, it is important not to diminish the areas of arable land to the detriment of photovoltaic/wind farms.

Waste recovery is another criterion that should not be neglected, making a direct reference to food waste and the selective collection of waste on at least four fractions.

In conclusion, to protect the environment, it is essential that the circular bioeconomy focus on major sectoral policies (agriculture, greenhouse gases, transport, waste, green energy) that can deliver tangible and sustainable results.

CAN CAMELINA CROP BE APPROACHED IN A SUSTAINABLE CIRCULAR BIOECONOMY?

Camelina sativa (L.) Crantz (family: *Brassicaceae*) can be approached in a sustainnable bioeconomy because it can be used in different domains such animal food, cosmetics, biofuels, oil for food industry, all of that in a 100% that means can be a fully friendly environment plant.

The main attractive features are: drought and frost tolerance, disease and pest resistance, a considerably high seed oil content, and satisfactory seed yields, in particular under low-input management and in limiting environments. The environmental benefits of the crop and a multipurpose applicability of the oil make *Camelina sativa* a promising oil-seed crop.

Circular bioeconomy can help to reduce competition for land and aquatic resources and thus contribute to the mitigation of climate change and biodiversity loss, but ultimately a coherent perspective on the main policy interventions is necessary.

Animal feeding has been identified to be a key factor in environmental sustainability. For this reason, by carrying out a life cycle assessment, there was many investigations focused on studying the environmental performance of the production of *Camelina sativa* in different regions of the world such as United States of America, Spain and France. For all of this utilities, *Camelina sativa* can be a part of circular economy in future.

A sustainable and circular bioeconomy would keep resources at their highest value for as long as possible through cascading biomass use and recycling, while ensuring that natural capital is preserved.

REFERENCES

Abramovic, H., Butinar, B., Nikolič, V. (2007). Changes occurring in phenolic content, tocopherol composition and oxidative stability of Camelina sativa oil during storage, *Food Chemistry*, 104(3), pages 903–909.

Belayneh, D. H., Wehling, R. L., Cahoon, E., Ciftcia, O. N. (2015). Extraction of omega-3-rich oil from *Camelina sativa* seed using supercritical carbon dioxide. *Journal of Supercritical Fluids*, 104, 153–159.

Belayneh, D. H., Wehling, R. L., Cahoon, E., Ciftci, O. N. (2018). Lipid composition and emulsifying properties of *Camelina sativa* seed lecithin. *Food Chemistry*, 242, 139–146.

Bernardo, A., Howard-Hildige, R., O'Connel, A. (2003). Camelina oil as a fuel for diesel transport engines, *Industrial Crops and Products*, 17(3):191–197, online Journal.

Berti, M., Gesch, R., Eynck, C., Anderson, J. (2016). Camelina uses, genetics, genomics, production and management, *Industrial Crops and Products*, Amsterdam.

Bonjean, A., Le Goffic, J., 1999. *Camelina - Camelina sativa* (L.) Crantz*: an opportunity for European agriculture and industry*, OCL, 6(1): 28–34.

Dobre, P., Jurcoane, S., Matei, F., Stelica, C., Farcas, N., Moraru, A.C. (2014). *Camelina sativa* as a double crop using the minimal tillage system, *Romanian Biotechnological Letters*, Vol. 19, No. 2, Bucharest, Romania.

Eynch, C., Shrestha, D., Vollman, J., Falk, K. C., Friedt, W., Singh, H. P., Obeng, E. (2013). *Sustainable Oil Crops Production*, Biofuel Crop Sustainability, John Wiley & Sons, Inc., 177, 181.

Feussner, I. (2015). Camelina - a promissing oilseed crop to contribute to the growing demand for vegetable oils, *European Journal of Lipid Science and Technology*, ISSN 1438-9312, online Journal.

Gurria, P., Ronzon, T., Tamosiunas, S., Lopez, R., Garcia Condado, S., Guillen, J., Cazzaniga, N. E., Jonsson, R., Banja, M., Fiore, G., Camia, A. and M'Barek, R. (2017). *Biomass flows in the European Union*, JRC Technical Reports, Joint Research Centre, Ispra, Italy.

Karvonen, H. M., Aro, A., Tapola, N. S., Salminen, I., Uusitupa, M. I., Sarkkinen E. S. (2002). *Effect of alpha-linolenic acid-rich Camelina sativa oil on serum fatty acid composition and serum lipids in hypercholesterolemic subjects*, Elsevier Science, USA.

Krohn, B. J., Fripp, M. (2012). A Life Cycle Assessment of Biodiesel Derived from the Niche-Filling Energy Crop Camelina in the USA, *Applied Energy*, onlie Journal.

Li, X., Mupodondwa, E. (2014). Life cycle assessment of camelina oil derived biodiesel and jet fuel in the Canadian Prairies, *Science of the total Environment*, 481(1):17–26, online Journal.

Moraru, A., Jurcoane, S., Dimitriu, D. (2013). Camelina cultivation for biofuels production, *Scientific Bulletin. Series F. Biotechnologies*, Vol. XVII, Bucharest.

Ni Eidhin, D., Burke, J., O'Beirne, D. (2006). Oxidative stability of omega3-rich Camelina oil and Camelina oil-based spread compared with plant and fish oils and sunflower spread, *Journal of Food Science*, Volume 68, Issue 1, online Journal.

Petre, S. M., Jurcoane, S., Dobre, P., Petcu, R., Dimitriu, D. (2013). Life Cycle Assessment: By-Products In Biofuels Production Battle; Rapeseed Vs. *Camelina sativa* L., *AgroLife Scientific Journal*, Vol. II (1), pg. 58–65.

Petre, S. M., Jurcoane, S. (2015). Life cycle assessment and potential of camelina meal for dairy cattle nutrition in romanian commercial farms, *Scientific Bulletin. Series F. Biotechnologies*, Vol. XIX, Bucharest.

Petre, S. M., Moraru, A., Dobre, P., Jurcoane, S. (2015). Life Cycle Assessment of Camelina sativa - Environmental friendly source for biofuels and livestock protein available in Romania? *Romanian Biotechnological Letters*, 20(4):10561–10571, online Journal.

Putnam, D.H., Budin, J.T., Field, L.A., Breene, W.M. (1993). *Camelina: a promising low input oilseed*, J. Janick and J.E. Simon (eds), New Crops. Wiley, New York, 314, 322.

Rokka, T., Alen, K., Valaja, J., Ryhanen, E.L. (2002). The effect of *Camelina sativa* enriched diet on the composition and sensory quality of hen eggs, *Food Research International*, 35(2):253–256, online Journal.

Ronzon, T., Lusser, M., Landa, L., M'barek, R., Giuntoli, J., Cristobal, J., Parisi, C., Ferrari, E., Marelli, L., Torres de Matos, C., Gomez Barbero, M. and Rodriguez Cerezo, E. (2017). *Bioeconomy report*, JRC Scientific and Policy Report EUR 28468 EN, Joint Research Centre, Brussels, Belgium.

Toncea, D., Necseriu, T, Prisecaru, L. N., Balint, M. I., Ghilvacs, M. (2013). The seed's and oil composition of Camelia - first romanian cultivar of camelina (*Camelina sativa* L. Crantz), *Romanian Biotechnological Letters*, 18(5), 8594, 8602.

Waraich, E. A., Ahmed, Z., Ahmad, R., Muhammad, Y. A., Saifullah, Naeem, M. S., Rengel, Z. (2013). *Camelina sativa,* a climate proof crop, has high nutritive value and multipleuses: a review, *Australian Journal of Crop Science*.

Waraich, Ejaz & Ahmed, Zeeshan & Ahmad, Rais & Ashraf, Muhammad & Ullah, Saifullah & Naeem, M.S. & Rengel, Zed. (2013). *Camelina sativa,* a climate proof crop, has high nutritive value and multiple-uses: A review. *Australian Journal of Crop Science*, 7. 1551–1559.

Zohary, D., Hopf, M. (2000). *Domestication of Plants in the Old World*, Oxford University Press, New York.

Zubr, J. (1997). Oil-seed crop: *Camelina sativa, Industrial Crops and Products*, Vol. 6, Issue 2, 16, pg. 113–119.

Zubr, J. (2003). Qualitative variation of Camelina sativa seed from different locations, *Industrial Crops and Products*, 17, 161–169.