RAPESEED AGROTECHNICS IN RELATION WITH THE QUALITY AND EFFICIENCY IN BIODIESEL PRODUCTION - REVIEW

Lovasz Andra*, Borza Ioana, Brejea Radu**, Sabău Nicu Cornel****

*University of Oradea, Doctoral School of Engineering Sciences, Agriculture, 1 University Str.410087, Oradea; LTC Bioliquid; Egusto Oil, 47 Roman Cirogariu Str. 410009, Oradea, România, e-mail a.lovasz@ltc-bioliquid.eu; a.lovasz@egusto-oil.eu
**University of Oradea, Faculty of Environmental Protection, 26 Gen. Magheru St., 410048, Oradea, Romania, e-mail: borzaioanamaria@yahoo.com; rbrejea@yahoo.com; nsabau@uoradea.ro

Abstract

This paper represents a documentation of the existing relations between the agrotechnichs of rapeseed culture in the production of biodiesel from pure rapseesd oil and from waste showing its quality and efficiency.

The pure biodiesel, called B100, is a monoalkylester of fatty acids derived from vegetable or animal oils. It is obtained chemically tru the transeterification reaction, where a glycerol reacts with an alcohol in the presence of a catalyst forming alkyl esters of fatty acids (crude biodiesel) and an alcohol (crude glycerin).

The raw materials used in the production of biodiesel from waste are mainly residues left over from the technological process of obtaining alimentary rapeseed oil

It will be compared the quality, quantity and economic efficiency of biodiesel obtained from pure oil and wate from each parcel of rapeseed and the best method of biodiesel production shall be determined.

Key words: rapeseed, biodiesel, waste, transesterification, esterefication

INTRODUCTION

The continuous increase in global energy consumption raises important issues for finding alternative sources of renewable and sustainable energy, environmentally friendly, to ensure energy security and socio-economic development. Has been set an energy efficiency target of at least 32.5% set by 2030. (C.E., 2019)

In Romania, the increase in primary energy consumption and the need to ensure energy independence, according to European Directives, must take measures to replace fossil fuels used in transport with biofuels, which would represent min. 20% by 2020. (CE Directive, 2009)

Considering the climate conditions, the agricultural potential and the social-economics aspects of Romania, rapeseed oil and its derivatives are among the most suitable biofuels (Energy / Climate Package, 2020) along with sunflower oil (Bunta and Baldini, 2008) and soy.

The rapeseed belongs to the family *Cruciferae,* genre *Brassica*, which includes 34 species. For oil is cultivated *Brassica napus* L. *ssp. oleifera*

Metzg *(rapseed colza) and Brassica campestris* L. *ssp. oleifera* D. C. (rapseed naveta). Both species have autumn and spring forms, the varieties of autumn forms being more productive. (Muntean et al., 2014)

In Romania, rapeseed was cultivated on larger areas before the First World War and between the two world wars. Thereby, in 1913, it occupied 80.38 thousand ha, and in 1930 approx. 77.32 thousand ha. After 1948, the areas varied from one year to another, passing a little over 20 thousand ha only in 1953, 1955, 1956. In 1935, the statistical yearbook of Romania mentions 5.9 thousand ha.(https://www.cartiagricole.ro/cultivarea-rapitei/?v=f5b15f58caba) The area cultivated with rapeseed in 2018 was 633 thousand ha, and the total national production was 1611 thousand tons. (Anghelache et al., 2020)

Rapeseed currently occupies a particularly important place in the world economy, as a source of vegetable oils. The seeds contain 42 - 48% oil used both in food, in the preparation of margarines and in industry. (Muste, 2001)

Rapeseed cultivation has multiple phytotechnical advantages: it is sown and harvested outside the crowded periods; has a favorable reaction to fertilization; allows the complete use of the same set of machines as for cereals; can be used as an excellent precursor for successive crops or for autumn cereals; raises soil fertility and prevents erosion on sloping lands; it is a good honey plant; the cakes being rich in protein (38 - 41.9%), carbohydrates (31.5 - 36.6%) and mineral salts (8 - 9.8%), have a good feed value; the epigee part of the plant (straw) can be used in the manufacture of particle board; it can also be used as green fodder in late autumn and early spring. (Muste, 2002; Guş et al., 2003; Guș et al., 2004)

Rapeseed also has some disadvantages due to: drought during sowing; the alternation between frost and thawing in spring and the frosts during the buding-flowering period. (Pirnă et al., 2011)

Biodiesel is an alternative fuel that can be used in pure form or in a mixture with diesel (Soriano et al., 2005), when burned in internal combustion engines. (Ingendoh, 2010) Pure biodiesel, called B100, is a monoalkylester of fatty acids derived from vegetable or animal oils. (Turck, 2003) It is obtained chemically by the transesterification reaction, where a glycerol reacts with an alcohol (methanol) in the presence of a catalyst (potassium hydroxide) forming alkyl esters of fatty acids (crude biodiesel) and an alcohol (crude glycerin). (Brighila, 2015)

MATERIAL AND METHOD

This study presents research results on the agrotechnics of rapeseed culture and its influence on the quality and economic efficiency in biodiesel production from pure oil and from waste. The aim of this study is to determinate which process leads to a greater reduction of the carbon dioxide emissions and other greenhouse gases involved.

RESULTS AND DISCUSSION

RAPESEED CULTURE TEHNOLOGY

Scientific classification. Rapeseed (*Brassica napus L.*) is part of the cruciferous plant family (*Brassicaceae*). (Figure 1) The flowers form pods of 5 - 10 cm with round seeds, color black - bluish till brown - bluish, weighing 1000 seeds between 3.5 and 6.5 g. Between the beginning of the flowering period and maturity is a distance of 70 days.

Figure 1. Rapeseed *(Brassica napus L.)*
(surce: https://upload.wikimedia.org/wikipedia/commons/5/57/Brassica_napus_-_K%C3%B6hler%E2%80%93s_Medizinal-Pflanzen-169.jpg;)

Rapeseed (*Brassica napus oleifera* and *Brassica rapa oleifera*) is a plant in the Brassicaceae cruciferous family with yellow flowers and a thin, long and branched stem. Its seeds are rich in oil used to produce biodiesel.

Rapeseed - canola is a registered trademark of a rapeseed hybrid, originally produced and cultivated in Canada, in areas with dry climates, excessive continental temperate. Rapeseed oil was produced in the 19th century as a source of lubrication for steam engines. The oil has a bitter taste due to the high level of acids. Canola was produced precisely to reduce this amount of acid, resulting in a tasty oil. (Dulf, 2008)

The rapeseed is cultivated on an area of over 27 million ha., Globally. The largest cultivators are China with 7.2 million ha and India with over 6.9 million ha, followed by Canada with 5.1 million ha, Germany with 1.3 million ha, and France with 1.2 million ha. The progress made worldwide and in our country in the improvement of this plant and in the multiple use of oil, fully motivates the reconsideration of the areas cultivated with this plant in

Romania as well.The vegetation period of the autumn varieties is 270-300 days and of the spring varieties 110-130 days. In the official catalog of plant varieties in Romania are registered 24 plant varieties. (Pirnă et al., 2011)

Place in crop rotation The best precursors for the autumn rape are the crops that release the soil early until the beginning of August, ensuring good soil preparation conditions, the accumulation of water necessary for emergence. (Samuil, 2007)

The best precursors are: autumn cereals (wheat and barley), early potatoes, legumes (peas), autumn borscht and red clover, after the first harvest. Spring rape can be sown after late harvests such as corn, sugar beet, potatoes, etc. Is not cultivate after soybeans and sunflowers, to prevent the spread of the attack of Sclerotinia sclerotiorum. Rapeseed can return to the same field after 3 years, and in case of Sclerotinia attack, after 7-8 years. (Harwood, 1985)

After rapeseed, most plants can be grown, because it releases the soil early and leaves the soil clean of weeds, being a good precursor for winter wheat.

Soil tillage Plowing will be carried out immediately after the release of the soil to a depth of 20-25 cm, in the aggregate with the star harrow. In the situation when the soil is dry and the plowing cannot be carried out without removing boulders, it is necessary to process the soil with the disc harrow in the aggregate with the harrow with adjustable fangs, following the plowing to be done after the first rain. Until sowing, the plow is kept clean of weeds, crushed and loosened by working with the disc harrow in the aggregate with the corner harrow.

The last work is performed with the combine at the sowing depth. If the soil is too loose, roll it before sowing, to ensure the incorporation of the seed at the optimum depth. At the time of sowing, the soil must be well crushed and settled. (Altieri, 1987)

Seed and sowing The seed must come from the year of sowing (it loses its germination by aging), to come from certified crops, from higher biological categories and have a minimum purity of 97% and a minimum germination of 85%.

The sowing period in the south of the country is September 5-15, and for the east, west and north of the country it is September 1-10. Both early and late sowing do not make the plants last well over the winter, and production decreases. In the first case, the plants enter the winter with a too vigorous vegetative mass, and in the second case there is a weak development of the plants until the coming of the cold season. (Zăhan 1983)

Spring varieties are sown early, in the first emergency, immediately after entering the field, because the rapeseed germinates at 2 - 3 ° C.

Bîlteanu, 2001, reports that the optimal sowing density in our country is 100 - 150 germinating grains / $m^{2,}$ to ensure 80 - 120 harvestable plants / m2. Large cultivating countries in Europe use densities between 50 and 80 plants / m2 for harvesting (Soltner, 1990). Volioud, 1992, quoted by Axinte, 2006, mentions that, in Switzerland, the largest harvests are made with 30 - 50 plants / m^2. For the pedoclimatic conditions in the Romanian Plain Georgescu et al., 2015, report the use for sowing rapeseed in experimental fields with a density of 60 plants / m2 (Table 1.)

Table 1.

Seed quantity and optimum density for autumn rapeseed cultivation

Nr. crt.	Seed quantity (kg/ha)	Density (plants/m^2)	Country	Author
1.	-	30 -50	Switzerland	Volioud, 1992; Axinte, 2006
2.	4 - 6	50 – 80	France	Soltner, 1990
3	3.5 - 4	-	Germany	Samuil, 2007
4	6 - 10	80 -120	Romania	Bîlteanu, 2001
5	-	60	Romania (Romanian Plain)	Georgescu et al., 2015

The quantity of seed is 6 -10 kg / ha, depending on the soil moisture and the quality of the germination bed, in order to have 80-110 plants / m2 at harvest. At these densities, a more uniform ripening is ensured, due to the reduction of the degree of plants branching, so the losses by shaking are reduced. In Germany, are used sowing quantities of only 3.5 - 4 kg / ha due to the varieties with a high degree of branching and the specific climatic conditions that favor this. (Samuil, 2007)

The sowing is done with the cereal seeders (SUP - 21, SUP - 29, SUP - 48) at the distance between rows of 12.5 cm and at the depth of 2-3 cm.

Works to be carried out immediately after sowing: the roller for bringing the seed into contact with the soil. Pre-emergent herbicide is the safest solution for keeping weeds clean until the ground is completely covered.

Fertilization. system Rapeseed is one of the crops with the highest specific consumption. For a ton of seeds and the related biomass production, the specific consumption is 50 - 60 kg nitrogen, 30 - 60 kg phosphorus, 40 - 50 kg potassium, 50 - 60 kg calcium, 20 - 30 kg sulfur and important quantities of microelements. (Muntean et al., 2014) According to Soltner, 1990, for 100 kg of seeds, plus the aerial part of the green mass, rapeseed consumes 2 kg N, 2.5 kg P_2O_5, 10 kg K_2O. (Table 2.)

For production, rapeseed plants use applied fertilizers and soil elements, depending on soil fertility. The soils in Romania "provide" to the plants annually between 20 - 60 (80) kg N, around 20 - 25 kg nitrogen for each percentage of humus. When fertilization has been inadequate, or climatic conditions have adversely affected nutrient uptake, symptoms of deficiencies in various chemicals may occur.

Table 2.

Fertilization system for autumn rape

Nr. crt.	Specification	Dose	Unit of measurement	Author	Observations
1	Specific consume (per tona of seed)			Muntean et al., 2014	
	Nitrogen (N)	50-60	Kg		
	Phosphorus (P)	30-60	Kg		
	Potassium (K)	40-50	Kg		
	Calcium (Ca)	50-60	Kg		
	Sulfur (S)	20-30	Kg		
2.	Specific consume (per 100 kg seed)			Soltner, 1990	
	N	2	Kg		
	P_2O_5	2.5	Kg		
	K_2O	10	Kg		
3	Fertilization with N			Sieling and Kage, 2010	Achieving 500-600 g / m2 at the end of winter
	Azot	35-45	Kg/ha		
	Mineral nitrogen (from soil)	45-60	Kg/ha		
4	Fertilization with P			Orlovius, 2016	Before sowing
	P_2O_5	50-80	Kg/ha		
5	Fertilization with K			Orlovius, 2016	The concentration in seeds is 0.9 - 1.0% K.
	K_2O	200-400	Kg/ha		
6	Fertilization with S			Hălmăjan et al., 2007	Optimum 20-30 kg/ha
	$(NH_4)_2SO_4$	125	Kg/ha		

The manure applied directly to the rapeseed crop in the amount of 20 - 30 t / ha, has determined the obtaining of economic increases, both for rapeseed and for the double crop that followed, or for the wheat sown in autumn (Bîlteanu and Bîrnaure, 1979) . In this case, the chiemical fertilizers are reduced by 1.0 -1.5 kg N, 0.75 kg P and 2.0 -2.5 kg K for each ton of manure.

Nitrogen fertilization in autumn At the end of winter, a promising rapeseed crop must have the biomass of the aerial part at least 500-600 g / sqm (fresh substance). To achieve this biomass, rapeseed plants absorb between 35 - 45 kg N / ha, which means that in the soil there must be between 45 - 60 kg of mineral nitrogen / ha at sowing. (Sieling and Kage, 2010)

Excessive increase in applied nitrogen doses, does not increase the amount of seed harvested. Also, the high doses of nitrogen administered reduce the amounts of obtained oil. (Béreš et al., 2019)

Phosphorus fertilization. Rapeseed is a crop with high phosphorus requirements. Some experts believe that phosphorus fertilizers can be applied at any time to keep a high level of mobile phosphorus in the soil. In most cases, it is best to fertilize with phosphorus before sowing. (Orlovius, 2016)

On soils poor in phosphorus, french specialists even recommend the application of fertilizers on plowing, so that, following the work of preparing the germination bed, rapeseed seedlings find phosphorus in the surface layers very quickly. (Soltner, 1990) If they had been applied before plowing, the fertilizers would be placed too deep for the young plants (at the bottom of the furrow) and would be inaccessible in the first phases of vegetation.

Non-phosphorus fertilization (especially on poorly supplied soils) severely penalizes the production. At rapeseed, phosphorus deficiencies can occur in the first phases of vegetation, even in the second week after emergence, because the phosphorus reserves in the seed is depleted in the first 7 days. (Grzebisz et al., 2018)

High phosphorus rates increase oil and protein content (Bailey and Grant, 1990) and cause rapeseed plants to mature faster.

Potassium fertilization Rapeseed with oilseeds has a high demand for potassium. The assimilation of potassium by winter rape in seeds is between 200 and 400 kg / ha K2O, although the concentration in seeds is relatively low, with values of 0.9 - 1.0% K in the dry matter. Thus, there is a considerable difference between the absorption of K by rapeseed and the removal of K from the field with the seeds, if the straw is not harvested but remains in the field. Although the export of potassium with the seeds from field is reduced to about 30 - 60 kg / ha K2O, growth is severely restricted by insufficient intake of K. (Orlovius, 2016)

In China, optimal potassium (K) fertilization is beneficial for the efficiency and quality of oilseeds (Brassica napus L.). However, the discrepancy between the high K demand for winter rape and the low soil fertility and the insufficient potassium intake, limited the sustainable development of rapeseed production. (Ren et al., 2013)

Sulfur fertilization. For rapeseed, sulfur is considered the third most important element, after nitrogen and phosphorus. (Poisson et al., 2019)

The best way to cover sulfur needs would be to use superphosphate. Due to the high sulfur content, fertilization with 125 kg of ammonium sulphate is sufficient to cover the sulfur needs of the rapeseed crop. Ammonium sulfate is cheap, but it is more difficult to apply, because it looks like a powder (fine crystals) that spreads with some difficulty. It should not be spread when the plants are wet or frozen. (Hălmăjan et al., 2007)

Ammonium sulfate also has the advantage of reducing the pH on basic soils, favoring the absorption of phosphorus. The optimal dose of sulfur (S) for rapeseed is 20-30 kg / ha. For rapeseed, the ratio of sulfur to nitrogen should be 1/7. Sulfate ions are soluble and easily leachable. Therefore, sulfur fertilizers (except superphosphate) should not be applied in the fall. (Hălmăjan, 2007)

Soltner, 1990, mentions crop increases of 2.25 - 3.70 q / ha by using sulfur fertilizers on some soils.

Chemical fertilizers applied alone are very well used. The absorption of nutrients takes place with intensity from the first phases of vegetation; but the largest amounts are absorbed in the period from the end of spring to the beginning of fruiting.

The doses of fertilizers for rapeseed cultivation depending on the planned production and the values of the agrochemical mapping, regarding the phosphorus, potassium and nitrogen index, are, in general, the following: nitrogen 80 - 180 kg; phosphorus 50 - 80 kg; potassium 60 - 80 kg. In the absence of agrochemical analyzes, the recommended doses are variable depending on the expected production: 80 - 180 kg N / ha, 50 - 120 kg P2O5 / ha and 65 - 150 K_2O / ha.

The full dose of phosphorus and potassium and 1/3 of the nitrogen dose will be applied under the basic plow, and the remaining 2/3 of the nitrogen dose will be given in early spring. Late fertilization around the formation of siliceous, aims to increase the mass of 1,000 grains. (Samuil, 2007)

Calcium amendments are applied to acid-reactive soils to correct for pH 6.5-7.5.

Care work. ***Chemical weed control*** is done with herbicides, Volatile herbicides are preferred because they control very well wheat or barley samulastra and many annual weed species, including Sorghum halepense from seed. It is applied pre-emergently and is incorporated by double threading.

Annual and perennial monocotyledonous species (rhizome crust) can be controlled by applying in vegetation (postemergent) selective herbicides such as: Fusilade forte l - 1.3 l / ha, Pantera, Targa super, Select super, 1.5 l / ha. Gallant super 1.0 l / ha. (Guș et al., 2003)

Pest control. Earth Fleas (Phyilottreta sp.) are controlled by treating the seeds with Nuprid AL 600 FS, 6 l / t of seed. (Georgescu et al., 2015) The stem weevil (Centorrhynchchus sp.) is controlled by Cruiser 35 CE treatments, 3 l / ha.

The glossy rapeseed beetle (Meligethes aeneus) is controlled with Fastac 10 CE - 0.075 l / ha by two treatments, with a break interval of 7 - 10 days.

The harvesting of rapeseed. Rapeseed is one of the agricultural plants for seeds that requires special attention in terms of establishing the time of harvest, due to the easy shaking of the seeds, registering shaking losses of 30 - 40 and even 50%.

Rapeseed is harvested when the plants are bent, the whole chain acquires a rusty yellow color, the sheaths are yellow-lilac, and on most seeds there is a brown spot.

Harvesting is carried out mechanically, in two phases, or directly with the grain combine. (Sims, 1979)

Harvesting in two phases is performed when the plants are yellow, and the seeds have started to turn brown and have a humidity of 25-30%. Cutting the plants in the ripening phase in the lever (yellow color of the silica and the seed with browning beginning) is done with the vindrover and remain on the stubble 25-30 cm high, until the seeds mature (until they reach a humidity of 12-14%) .

After a few days, when the seeds reach full maturity and the humidity decreases to 12-14%, the plants are threshed on the go with the combine, cutting the stubble under the rapeseed furrow, making the necessary changes to prevent the loss and breaking or peeling of the seeds. .

The direct harvest with the combine will be carried out 5 - 7 days after the application of the Reglone desiccant, 2 - 3 l / ha and 150 - 200 l of water, in the phase when the siliceous turned yellow-lilacs and the coloring of the seeds started. At the time of harvest, the seed moisture should be around 16%. The work is performed in the evening, in the morning and during the night.

The seeds are immediately cleaned and dried at a humidity of 9-10%. When immediate drying cannot be ensured, the storage will be done in layers of 5 - 10 cm, with the capsule on, and will be shoveled until the humidity drops to 10%. (Muste, 2002)

The obtained productions are between 2.000 – 4.000 kg / ha. The average rapeseed production in Europe in recent years has been around 2,800 kg / ha. The ratio between seed and straw production is 1: 1.5 - 2.0.

THE TEHNOLOGICAL PROCESS OF OBTAINING BIODIESEL

Agricultural crops used for the production of biofuels and biomass energy are called energy crops. Romania's potential in biomass energy production is estimated at 65% of the total green energy potential. (Brighila, 2015). 75% of the world's biodiesel is produced in European Union countries, with Germany producing over 50%, meaning 1.03 million tonnes in 2004. (17th International Congress for Renewable Mobility "Fuels of the Future", 2020)

World biofuel production has increased by an average of 11.4% in the last ten years. Biodiesel production increased by 4% in 2018, the main countries supplying biodiesel are mainly Indonesia, India, China, Norway, Hong Kong, Argentina taking the lead in the production and supply of rapeseed biodiesel to EU countries. The biodiesel market is expected to grow remarkably between 2018 and 2023 (Figure1.)

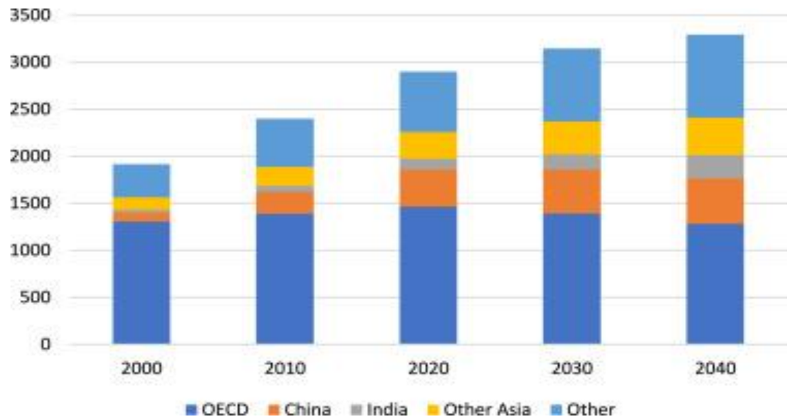

Fig. 1. Global demand for biodiesel in transport
(Source: Oyetola and Noor 2019)

An analysis of the European Commission's agricultural data shows that 53% of the raw materials used to produce biodiesel from crops in the EU in 2015 (approx. 3400 trillion liters) were imported. In 2016, 33% of biodiesel in EU crops comes from imported palm oil. (Figure 2.)

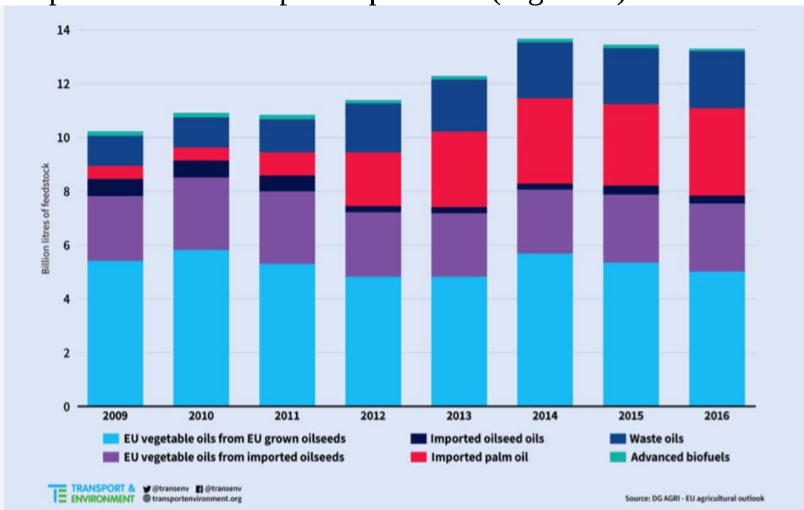

Fig.2. Raw material used for biodiesel production (2009-2016)
(Source: https://www.transportenvironment.org/press/around-half-eu-production-crop-biodiesel-based-imports-not-crops-grown-eu-farmers-new-analysis)

Due to the fact that between 2005 and 2015, total consumption of vegetable oil in the EU decreased in the food sector (from 15.1 to 13.7 million tonnes), while bioenergy production increased 4 times (from to 2.9 to 10.5 million tonnes), mainly due to biodiesel, produced in proportion of 60% from rapeseed. Also, the production from oil residues predominates, to the detriment of crude oil. (https://www.transportenvironment.org/press/around-half-eu-production-crop-biodiesel-based-imports-not-crops-grown-eu-farmers-new-analysis)

So, it can be noticed that there is a growing trend in rapeseed areas in Europe and a growing concern for the economic efficiency of rapeseed biodiesel production.

The process of obtaining biodiesel is very easy, involving a reaction of a vegetable oil with an alcohol (methanol), in the presence of a catalyst, resulting an ester (biodiesel) and glycerin. This ester can replace diesel fuel in most diesel engines. It is biodegradable, renewable and non-toxic, with a low level of pollutants. (Baldini et al., 2003). In the case of biodiesel produced from rapeseed, the raw material can be pure (crude) oil or various residues from the oil.

The process of obtaining biodiesel from pure oil. Pure vegetable oil is an oil produced from oilseeds by pressing, extraction or comparable processes, crude or refined, but not chemically modified. Of these, rapeseed is best suited for biofuel.

To obtain crude oil from rapeseed before pressing, it is necessary to clean, dry, peel (resulting in husks, ash and furfural) ground and burned. (Găgeanu, 2012) After pressing results crude press oil which is the raw material for biodiesel, and broken cakes. (Figure 3.)

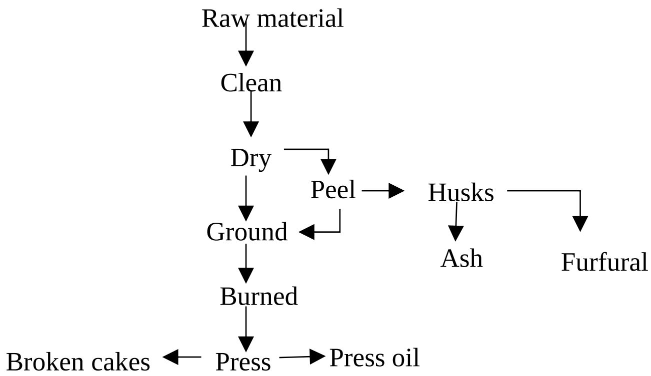

Fig.3 The process of obtaining oil and residues

After the purification of the rapeseed oil, in order to obtain the biodiesel it is necessary to go through the following steps:

Transesterification (Ingendoh, 2010) is the chemical reaction between an ester (vegetable oil) and an alcohol (Methanol) in the presence of a catalyst (KOH - Potassium Hydroxide)

1. The purification of the resulting material will be performed by sedimentation..
2. Washing with acidic water to remove any free fatty acids left after transesterification. (Brighila, 2015)
3. Wash with neutral water to reduce acidity after acid washing.
4. Drying - heating the biodiesel to 130^0C to evaporate the water content.

The process of obtaining biodiesel from waste. The technological process is cheaper, due to the low price for the raw material, but it involves additional steps (Turck, 2003), being more complicated than in the case of using pure oil:

1. Separation of fatty acids from residues: the reaction takes place in the presence of an acid (96% concentrated sulfuric acid) and steam (up to a temperature of 100 ^{0}C) the result being fatty acids and acidic water.
2. Sedimentation causes fatty acids to rise to the surface and acidic water to settle to the bottom
3. The process of esterification under pressure using an acid (Methanesulfonic acid) and an alcohol (Methanol) the result being the crude ester and water. This reaction takes place at a pressure of 5 bar and a temperature of 130 ^{0}C. (Ingendoh, 2010)
4. The crude ester refining process: here the glycerin phase of the tranesterification process will be used to reduce free fatty acids. (Turck, 2003)
5. The process of tranesterification of crude ester
6. Purification of biodiesel.
7. Acid washing.
8. Neutral washing.
9. Drying of biodiesel.

Given the agrotechnics of rapeseed cultivation and the technological process of obtaining biodiesel, there is the problem of identifying possibilities to increase economic efficiency given the quantity and quality of biodiesel produced.

The economic efficiency of biofuel production is largely influenced by the amount of vegetable oils and their derivatives and last but not least by the quality of diesel substitutes.The quantity of vegetable oils is directly dependent on the economic efficiency of the agricultural farm, and implicitly on the price of the production of raw material (seeds) for the production of biodiesel. (Mateoc – Sîrb et al., 2013)

The quality of biodiesel obtained, either from crude oil or from oil residues can be assessed by laboratory analysis of physicochemical properties, such as: ester content, density, flash point, CFPP (limit of filterability), cloud point, sulfur content, ash content, water content, total contamination, oxidation stability, acidity value, iodine value, Linolenic acid-methyl ester content (C18: 0), methanol content, monoglyceride - diglyceride - triglyceride content, content of free glycerin, total glycerin content, alkali metal content (Na + K), alkaline earth metal content (Ca + Mg), phosphorus content. (Beşleagă et al., 2015)

CONCLUSIONS

Biodiesel production has increased significantly in Europe even in Romania. Rapeseed, the energy plant from which the best biodiesel is produced, was cultivated in Romania in 2018 on 611 thousand ha.

Agricultural rapeseed production is directly dependent on soil and climatic conditions (climate, topography and especially soil fertility) and last but not least on the applied cultivation technologies. Among the important technological links are: the quantity of seed used for sowing, the density of plants at the end of winter (Bîlteanu, 2001; Georgescu et al., 2015) and especially the applied fertilization system (Hălmăjan et al., 2007; Muntean et al., 2014)

Studies have shown that the administration of high doses of single nitrogen does not always lead to an increase in the production of rapeseed, nor to an increase in the amounts of oil obtained. (Béreš et al., 2019) being necessary the application in complex with the other fertilizing elements. The importance of sulfur fertilization was also detached (Poisson et al., 2019) indicating the S: N ratio of 1: 7

High doses of applied phosphorus to rapeseed cultivation increase the content of oil and protein and cause faster maturation of plants. (Bailey and Grant, 1990). The export of potassium from the soil with rape seed is reduced to about 30 - 60 kg / ha K_2O, but nevertheless insufficient intake of K severely restricted plant growth. (Orlovius, 2016)

Therefore, the efficiency of rapeseed production, and implicitly of the amount of oil obtained, implies the application of a balanced fertilization system.The biodiesel produced from waste is more common than that produced from pure oil, but the applied technology involves a greater number of steps in the case of waste.

The quality of the biodiesel obtained depends, first of all, on the applied technological process, from crude oil and / or from oil residues. It can be estimated that in the first case a high quality biodiesel results, compared to the one obtained from residues, but the price of rapeseed is higher than the price of oil residues. Also a particular importance are the production costs, the price / quality ratio being decisive.

REFERENCES

1. Altieri M.A., 1987, Agroecology: The scientific basis of alternative agriculture. Intermediare Technology Publications: London
2. Anghelache C., Dumitru D., Stoica R., 2020, Studiu privind evoluția activității agricole în România în anul 2019, Romanian Statistical Review - Supplement nr. 4, pg. 158-170
3. Axinte Mh., 2006, Fitotehnie, Editura "Ion Ionescu de la Brad" Iași
4. Bailey L.D., Grant C.A., 1990, Fertilizer placement studies on calcareous and non-calcareous Chernozemic Soils: growth, P-up-take, oil content and yield of Canadian Rape, Communications in Soil Science and Plant Analysis, Vol.21, Is. 17-18, pg. 2089-2104
5. Baldini M., Vischi M., Di Bernardo N., Turi M., Vanozzi G.P., Olivieri A.M., 2003, High oleic sunflower varieties for biodiesel: a new perspective for sunflower crop. Proc. XLVII It. Soc. Agr. Gen. Ann. Congress, Verona, Italy, 24/27 sept. pg. 3-15
6. Beșleagă Ig., Lăcustă I., Popușoi V., 2015, Studiul proprietăților fizico-chimice ale biocombustibililor pentru MAC, Universitatea Agricolă de Stat a Moldovei, pg.311-315

7. Bîlteanu Gh., Bîrnaure V., 1979, Fitotehnie, Editura Ceres, pp. 910
8. Bîlteanu Gh., 2001. Fitotehnie, vol. 2 – Oleifere, textile, tuberculifere şi rădăcinoase, tutun, hamei, medicinale şi aromatice. Editura Ceres, Bucureşti.
9. Béreš J., Bečka D., Tomášek J., Vašák J., 2019, Effect of autumn nitrogen fertilization on winter oilseed rape growth and yield parameters, Plant, Soil and Environment, vol. 65, no. 9, pg: 435 – 441 (https://www.agriculturejournals.cz/publicFiles/444_2019-PSE.pdf)
10. Brighila Fl., 2015, Obținerea biodiselului prin transesterificare (prezi.com) https://prezi.com/ha5kde9joe_k/obtinerea-biodieselului-prin-transesterificare/ (Accesat: 12.12.2020)
11. Bunta Gh., Baldini M., 2008, The first results regarding the breeding of some sunflower hybrids for biodiesel, Analele Universității din Oradea, Fascicula Protecția Mediului, Vol. XIII, pg. 33-38
12. Comisia Europeană (C.E.), 2019, Raport al Comisiei către Prlamentul European și Consiliu, Evaluarea pentru 2018 a progreselor realizate de statele membre în direcția realizării obiectivelor naționale de eficiență energetică pentru 2020 și în direcția punerii în aplicare a Directivei privind eficiența energetică, conform articolului 24 alineatul (3) din Directiva 2012/27/UE privind eficiența energetică, Bruxelles, 9.4.2019,COM(2019)224 final, pg. 18
13. Directiva 2009/28/CE a Parlamentului European și a Consiliului din 23 aprilie 2009 privind promovarea utilizării energiei din surse regenerabile, de modificare și ulterior de abrogare a directivelor 2001/77/CE și 2003/30/CE
14. Dulf F.V., 2008, Rapedeed oil as biodiesel resource and adulteration for expensive edible oils, ProEnvironment, Vol 1, pp.32-38
15. Găgeanu P., 2012, Extragerea uleiului din semințele de rapiță și purificarea acestuia, INMA București, pp. 32
16. Georgescu Em., Cană Lidia, Gărgăriță R., Râșnoveanu Luxița, 2015, Probleme actuale privind combaterea puricilor de pământ (*Phyllotreta Spp.)* din cultura rapiței de toamnă, în Câmpia Română, An. I.N.C.D.A. Fundulea, Vol LXXXIII, pg. 157-178
17. Grzebisz W., Szczepaniak W., Barłóg P., Przygocka-Cyna Katarzyna, Potarzycki J., 2018, Phosphorus sources for winter oilseed rape (Brassica napus L.) during reproductive growth – magnesium sulfate management impact on P use efficiency, Archives of Agronomy and Soil Science, Vol. 64, Is. 12, pg. 1646-1662
18. Guş P., Rusu T., Bogdan Ileana, 2003, Agrotehnică, îndrumător de lucrări practice, Editura Risoprint, Cluj-Napoca
19. Guş P., Rusu T., Bogdan Ileana, 2004, Asolamentele, rotaţia culturilor şi organizarea teritoriului. Editura Risoprint Cluj-Napoca
20. Harwood R.R., 1985, The integration efficiencies of cropping systems. In : Edens, T. et.al. (eds). Sustainable Agriculture and Integrated Cropping Systems. Michigan State University Press.
21. Hălmăjan H.V., 2007, Practici de fertilizare la cultura rapiței, AgriPlus nr. 12, pg. 21-22.
22. Hălmăjan H.V., Vasile Gina, Ciubotă Gh., 2007, Fertilizarea suplimentară cu azot și sulf a plantelor de rapiță, Lucrări Științifice, vol 50, Seria Agronomie, pg. 321-324, Universitatea de Științe Agricole și Medicină Veterinară Iași
23. Ingendoh Ax., 2010, Method for Manufacturing Biodiesel by Acid Transesterification, and use of Sulphonic Acid as a catalyst in the manufacture of biodisel, European Patent Specification, Nr. PCT/EP2010/004950, 12.08.2010
24. Mateoc–Sîrb N., Zagoni A., Mateoc T., Sârb Gh.S., Grad I., Pîrşan P., Duma- Copcea A., 2013, Cercetări cu privire la eficiența cultivării plantelor energetice și obținerea de biocombustibil în România, Economie, pg. 50-53
25. Muntean L.S., Cernea S., Morar G., Duda M.M., Vârban D.I., Muntean S., Moldovan Cr., 2014, Fitotehnie, Ed. Risoprint, Cluj-Napoca
26. Muste S., 2001, Materii prime vegetale, vol. I. Ed. Risoprint, Cluj-Napoca
27. Muste S., 2002, Materii prime vegetale, vol. II. Ed. Risoprint, Cluj-Napoca
28. Orlovius K., 2016, Fertilizing for high yield and quality oilseed rape, International Potash Institute, IPI Bulletin no.16, Edited by Dr. E.A. Kirkby, pg.125, Basel, Switzerland
29. Oyetola O., Noor A., 2019, A review of global current scenario of biodiesel adaption and combustion in vehicular diesel engines, Energy Reports, vol. 5, pg 1560-1579
30. Pachetul energie/climă, 2020 (https://eur-lex.europa.eu/legal-content/RO/TXT/HTML/?uri=LEGISSUM:2001_8&from=RO;) Accesat: 01.02.febr.2021)
31. Pirnă I., Voicu Em., Vlăduț V., 2011,Tehnologia de cultivare a rapiței, INMA București, Proiect P2
32. Poisson E., Trouverie J., Brunel-Muguet S., Akmouche Y., Pontet C., Pinochet X., Avice J-C., 2019, Seed Yield Components and Seed Quality of Oilseed Rape Are Impacted by Sulfur Fertilization and Its Interactions With Nitrogen Fertilization, Frontiers in Plant Science, Vol. 10, Art. 458, pg. 1-14
33. Ren T., Lu J., Li H., Zou J., Xu H., Liu X., Li X., 2013, Potassium-fertilizer management in winter oilseed-rape production in China, Journal of Plant Nutrition and Soil Science,Vol.176, Is. 3, pg. 429-440
34. Samuil C., 2007, Tehnologii de agricultură ecologică, Iaşi
35. Sieling Kl., Kage H., 2010, Efficient N management using winter oilseed rape. A review, Agron. Sustain. Dev. Vol. 30, pg. 271–279
36. Sims E. H. Ralph, 1979, Comparative methods of harvesting oilseed rape, New Zealand Journal of Experimental Agriculture, vol. 7, no.1, pg. 79-83 DOI: 10.1080/03015521.1979.10426167
37. Soltner D., 1990, Les bases de la production végétale. Tome 1:le sol. Sainte Gemmes sur Loire (Angers) [FRA] : Collection Sciences et Techniques Agricoles, p. 467, France
38. Soriano N.U., Migo V.P., Matsumura M., 2005, Vegetable oil-based pour point depressant for neat biodiesel. Am. Oil Chem. Soc. (AOCS), Salt Lake City, USA, May 1-4.
39. Turck R., 2003, Method for producing fatty acid esters of monovalent alkyl alcohols and use thereof, United States Patent Nr. US 6,538,146 B2 Date of Patent: Mar. 25, 2003
40. Zăhan P., 1983, Elemente tehnologice la cultura rapiței de toamnă în condițiile solurilor podzolice, AGRIS
41. * * * 17th International Congress for Renewable Mobility "Fuels of the Future", 2020, Berlin, Germany (https://bioenergyinternational.com/opinion-commentary/fuels-of-the-future-2020-is-putting-biomethane-on-the-road)
42. * * * Cultura Rapitei - tehnologia de cultura in Romania pas cu pas (cartiagricole.ro) https://www.cartiagricole.ro/cultivarea-rapitei/?v=f5b15f58caba (Accesat 22.12.2020)
43. * * * https://www.transportenvironment.org/press/around-half-eu-production-crop-biodiesel-based-imports-not-crops-grown-eu-farmers-new-analysis (Accesat 08.02.2021)
44. * * * https://upload.wikimedia.org/wikipedia/commons/5/57/Brassica_napus_-_K%C3%B6hler%E2%80%93s_Medizinal-Pflanzen-169.jpg; (Accesat 02.02.2021)