THE PUBLISHING HOUSE
OF THE ROMANIAN ACADEMY

SUSTAINABILITY MEASUREMENT IN PRACTICE CASE STUDY "ORGANIC CAMELIA VARIETY OF CAMELINA SATIVA (L) CRANTZ METADATA"

Ion TONCEA[1] and Vladimir Adrian TONCEA[2]

[1] National Agricultural Research and Development Institute Fundulea
[2] Faculty of Management and Rural Development of University of Agronomic Sciences and Veterinary Medicine of Bucharest

Corresponding author: Ion Toncea: tonceaion@gmail.com

Received November 19, 2024

How can be measure sustainability? is one of the three scientific challenges regarding sustainability, the other two – What is sustainability? and How can we make sustainable development a reality?, remaining unanswered, for now. In order to develop the sustainability measurement model and its validation are used metadata from 2009–2013 period, from two scientific papers about Camelia variety of Camelina sativa (L.) Crantz, mainly the seed yields and their content (%) in protein, fat and carbohydrate, respective in elemental components (C, H, S, O, N and Ash) which have energy value. The new data refers to energy consumption (Inputs) with the activities carried out and the materials used in the cropping system and energy yields (Output) of Camelina Camelia cultivated in autumn and spring, calculated based on Atwater specific factor for protein, fat and carbohydrate, respective with Channiwala and Parikh formula of the gross calorific value of the elemental components. Based on metadata and new scientific and practical data and on adequate references, it was find that: 1) the sustainability refers to system and its lifetime energy production and consumption; – the sustainability of system can be estimate/measure by an energy balance model; 2) the sustainability has two indicators – Net energy, and Net energy rate; and that sustainable systems are only those that produce significant more energy than is consumed in their establishment and maintenance.

Also, the sustainability indicators – Net energy and Net energy rate, are essential and easy to calculate and monitor sustainability of any agroecology system or agroecosystem, mainly for the cropping systems with highest potential photosynthetic.

Keywords: sustainability, energy, sustainability measurement, Camelia Camelina sativa (L.) Crantz

INTRODUCTION

Sustainability word is often used in the scientific world and beyond, since 1972 when were used in the United Nations Conference on the Human Environment in Stockholm[9].

The debates and studies on sustainability intensified after World Commission on Environment and Development published of the paper "Our Common Future", so-called "Brundtland Report"[11]. These discussions culminated in the summit meeting in Rio de Janeiro in 1992, which established the objectives of sustainable development, summed up in a single phrase: *Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs*[11].

As it turns out in the article "The 3 pillars of sustainability: environmental, social and economic (ESG)"11, the sustainability field is very rich in theory and useful practices today by:

– defining of the environmental, social and economic (governance) sustainability;

– establishing the goals should aim to achieve ESG pillars of sustainability;

– identification of factors influencing ESG pillars of sustainability;

– the guideline and practical actions for implementation of "Ethics", the pillar 4 of sustainability and its characteristics – integrity, transparency, fairness, respect for diversity and promotion of collective welfare;

– integration strategy of the sustainability ESG pillars;

However, after 52 years of history of sustainability, there are 3 FAQs on the ResearchGate website: What is sustainability? How can we make sustainable development a reality? How sustainability can be measured?

This paper refers to the question “How sustainability can be measured”, a subject with small interest from scientific communities, for the moment, *e.g*. in the Sustainability measurement paper of Wikipedia[12], it is just a topic from 85 references and it is quoted only 8 times in text. Also, in “The 3 pillars of sustainability: environmental, social and economic”[11], the measurement of sustainability is quoted 22 times, mainly when it is write about the dimensions (pillars), indicators, tools, guidelines etc of sustainability.

A justification is that *Sustainability is difficult to quantify because the Environmental, Social and Governance (ESG) revolution has seen a torrent of standards and certification systems, metrics, data points, indices etc*[4]. Also, *it may even be impossible to measure sustainability as there is no fixed definition of sustainability and the measurement sustainability is an engaging in a futile exercise of measuring the immeasurable*[4].

In this context, the answer at “How sustainability can be measured?”[6] is, at least, *a fascinating and useful viewpoint on the long vexed question of how to measure sustainability*[1] as Jack Broughton, a scientist member of ResearchGate Sustainability group, said. Also, it is expected that energy yield potential of Camelia variety of Camelina sativa (L.) Crantz, to be, as in case of any green crop, much higher than consumption, thanks to the miraculous process of photosynthesis by which the mineral substances are transformed into organic substances, proportional with sunlight and plant chlorophyll content[5]. As results from the next chapters, the model of sustainability measurement based on energy has important application potential for any agroecology system or agroecosystem, mainly for the cropping systems with high potential photosynthetic.

MATERIALS AND METHODS

In the perspective of the sustainability measurement model validation, in this paper it is used metadata (data about data) from two scientific papers about Camelia variety of Camelina sativa (L.) Crantz[7,8], regarding: seeds yields in dry matter (DM) from 2009–2013 period, and their content (%) in proteins, fats and carbohydrates, as well as in the chemical elements (C, H, S, O, N and Ash) which have energy value.

Among the data required for the sustainability measurement model, in the above scientific papers are missing those on the energy value of the materials and of labor consumed (inputs) for cultivation of camelina Camelia (Table 1).

Table 1

The calorific value of inputs for cultivation of Camelia variety of Camelina sativa (L.) CRANTZ

Name of materials and labor inputs	Units of measure	Gross calorific value (kJ/unit measure)	Sources
Diesel fuel	liter	38,290	https://www.google.com/search?q=calorific+value+of+diesel+in+kj%2Flitre&sca_esv=02c44965d6d4b280&sca_upv=1&sxsrf=ADLYWII5l8Z5xjO4O5vA4EYqP2fen6IkUw%3A1727278492729&ei=nC30Zq2aLNiN9u8PtvjY-Q&oq=calorific+value+of+diesel+per+litre&gs_lp[17]
Electricity	kWh	3,600	https://en.wikipedia.org/wiki/Kilowatt-hour#:~:text=The%20International%20System%20of%20Units,3%2C600%20kilojoules%20or%203.6%20MJ[15].
CuSO4 *(estimated)*	kg	9.715	https://www.google.com/search?q=Calorific+value+of+Cu&oq=calorific+value+of+cu&gs_lcrp[18]; https://www.google.com/search?q=calorific+value+of+sulfur&sca_esv[19]
Man day	1 Day	12,552	Ion Teșu. și Vasile Baghinsch (1984) - Energia și Agricultura, Edit. Ceres[5], ”pp. 243 – 245”
Seeds (rape)	kg	29,100	https://www.feedtables.com/content/rapeseed-whole[16]

Also, the other new data are:

– The yield of proteins, fats and carbohydrates (kg ha^{-1}), which is calculated according to the seeds production (kg ha^{-1}), in dry matter (DM) and the protein, fat and carbohydrates content (%) of these seeds.

– Energy yield – the sum of the energy of seeds proteins, fats and carbohydrate calculated by multiplied of each of these energy components with the Atwater (energy) specific factors (Table 2), respective, the sum of energy content of seeds elements (C, H, S, O, N and Ash), in the case of the gross calorific power calculation formula[10].

For estimating the amount of energy of protein, fat and carbohydrates based on Atwater general energy factor, the most scientific works use a single Atwater factor – 16 kJ/g for protein and carbohydrates and 37 kJ/g for fat. In the following, it will be use the average value (kJ/kg) of the variation range of the Atwater specific factor for amount of protein (15879 kJ /kg), fat (36380 kJ/kg) and carbohydrates (16276 kJ/kg) (Table 2).

Table 2

Atwater specific factors of the main energy sources of plants

Atwater energy factors	Sources
• Protein energy factor: 3.59–4.0 kcal/g (3.8 kcal/g); 15.021–16.736 kj/g **(15879 kJ/kg)**	https://www.fao.org/4/y5022e/y5022e04.htm[13]
• Fat energy factor: 8.37–9.02 kcal/g (8.70 kcal/g); 35.021–37.73968 kj/g **(36380 kJ/kg)**	
• Carbohydrate energy factor: 3.78–4.0 kcal/g (3.89 kcal/g); 15.81552–16.736 kJ/g **(16276 kJ/kg)**	

The gross calorific value (HHVC) of organic Camelina Camelia seeds, was estimate with the Channiwala and Parikh formula[10]:

HHVc = 34910 × Ci + 117830 × Hi + 10050 × Si + 10340 × Oi – 1510 × Ni – 2110 × Ai, in which the symbols Ci, Hi, Si, Oi, Ni and Ai signify the content of the seeds in Carbon, Hydrogen, Sulphur, Oxygen, Nitrogen, and Ash. The content of the Camelina Camelia seeds in these elements is those from table 7 of the paper *The seed's and oil composition of Camelia – first Romanian cultivar of Camelina sativa (L.) Crantz*[8]: 58.9% C, 8.6% H, 0.3% S, 20.045% O, 3.7% N and 4.193% A.

– Net (Efficiency) energy: difference of the output of the energy and the input of the energy;

– Net (Efficiency) energy rate[14]: the ratio of the output of the energy to the input of the energy;

Also, the Net-energy rate is appreciate depending on the results of analysis of variance (one-way ANOVA), and of test of two hypotheses:

h1 – The system produce more energy than consume;

h2 – The energy produced of a system is significant more than energy consumed of it.

The energy is expressed, everywhere, in kilojoules (kJ), according recommendation of the International Union of Nutrition Science, as the preferred unit for all form of energy[2].

RESULTS AND DISCUSSIONS

The paper answer at question “How can be measured sustainability” through a model suggested by Bill Mollison, father of Permaculture, in October 2017 in an interview found on YouTube regarding sustainable model[3]: *A sustainable system is any system that in its lifetime can produce more energy than it takes to establish and maintain it.*

Therefore: Ss[6] = ∑Ep – ∑Ec,

in which:

Ss – Sustainability of the system;

Ep – energy produced by the system (Outputs);

Ec – energy consumed (Inputs) to set-up and maintain the system during its lifetime;

p and c = 1 to n and

n – number of the energy components or elements produced, respective consumed by the system.

Also, the model of Sustainability measurement is similar with net energy or energy balance models.

Energy Inputs in Organic system of Camelia variety of C*amelina sativa (L.) CRANTZ*

It is a common indicator of both Sustainability measurements procedures and consist in estimation of energy inputs based on annually energy of the materials and manpower consumed/ha for cultivation of Camelina Camelia during 2009–2013 period.

According to Table 3, in each year it was used the same technology, but specific of the sowing time. In this case, the total inputs were 2595783 kJ ha^{-1} at autumn organic Camelina, and 3870076 kJ ha^{-1} at spring organic Camelina. The surplus of energy consumed at spring Camelina is due to the autumn ploughing, one of the energy intensive soil tillage, because needs the highest diesel fuel quantity (28 l/ha). The energy inputs include, also, the energy flat rate (25% of total energy inputs), to cover other energy costs, like taxes of the land, manpower, yields etc. as well the energy value of some inputs, such us CuSO4 whose energy value is estimated. Since a diverse range of fertilizing and plant protection products, now used in Camelina cultivation technology, including organic certified, it is imperative these products to be analysed to find out their gross calorific value.

Table 3

Agricultural production activities and the energy consumed (inputs) in organic system of Camelia variety of Camelina sativa (L.) Crantz (NARDI Fundulea, 2009–2013)

Agricultural work carried out (tillage, fertilization, sowing, plant protection, harvesting, storage, selection, cleaning, utilization)	Materials and man power (the name)	Quantity (Units of measure/ha)	Energy consumed (Inputs) (kj/ha)
Autumn organic Camelina Camelia			
Crop rotation design	Man days	2/8 ha	252
Chopping plants debris from previous crop	Diesel fuel	4,0 l	153160
Disking land	Diesel fuel	6,5 l	248885
Cleaning and seed treatment	Electricity	1 Kwh	3600
	CuSO4 (10%)	12,5 ml/kg	117
	Man days	1/8 ha	126
Working land with cultivator x 2 times	Diesel fuel	8 l/ha	306320
Sowing	Diesel fuel	5,0 l	191450
	Seeds	10 kg	291000
	Man days	1/8 ha	126
Spring harrowing	Diesel fuel	5,0 l	191450
Manual weeding	Man days	1/8 ha	126
Harvesting	Diesel fuel	14,3 l	547547
	Man days	1/8ha	126
Crop monitoring	Man days	10/8ha	12552
Other energy consumed (flat rate = 25%)			*648946*
Total energy consumed (kj/ha)			2595783
Spring organic Camelina Camelia			
Crop rotation design	Man days	2/8 ha	252
Chopping plants debris from previous crop	Diesel fuel	4,0 l	153160
Disking land	Diesel fuel	6,5 l	248885
Ploughing	Diesel fuel	28 l/ha	1072120
Cleaning and seed treatment	Electricity	1 Kwh	3600
	CuSO4 (10%)	12,5 ml/kg	116.58
	Man days	1/8 ha	126
Working land with cultivator x 2 times	Diesel fuel	8 l/ha	306320
Sowing	Diesel fuel	5,0 l	191450
	Seeds	6 kg	174600
	Man days	1/8 ha	126
Spring harrowing	Diesel fuel	5,0 l	191450
Manual weeding	Man days	1/8 ha	126
Harvesting	Diesel fuel	14,3 l	547547
	Man days	1/8ha	126
Crop monitoring	Man days	10/8ha	12552
Other energy consumed (flat rate = 25%)			*967519*
Total energy consumed (Kcal/ha)			3870076

The energy yield of Camelia variety of Camelina sativa (L) Crantz based on Atwater specific factors

The energy yield of organic Camelina Camelia depends, first on yield of the energy components of seeds: 141–260 kg ha^{-1} protein, 258–512 kg ha^{-1} fat and 89–153 kg ha^{-1} carbohydrate at autumn Camelina Camelia, respective 84–289 kg ha^{-1} protein, 161–629 kg ha^{-1} fat, 58–169 kg ha^{-1} carbohydrate at spring Camelina Camelia (Table 4).

Table 4

The content (%) and yields (kg ha^{-1}) of main energy components of the organic seeds of Camelia variety of Camelina sativa L. Crantz (NARDI Fundulea 2009–2013)

Year	DM yield (kg ha^{-1})	Content (%) and yield (kg ha^{-1}) of the main energy components of seeds			Other components	
		Protein (%/kg ha^{-1})	Fats (%/kg ha^{-1})	Carbohydrates (%/kg ha^{-1})	Ash (%)	Water (%)
Autumn Camelina Camelia						
2009	1154	19.68/**227.11**	44.35/**511.80**	11.3/**130.40**	4.25	6.4
2010	869	20.86/**181.27**	30.10/**261.57**	12.8/**111.23**	4.32	5.9
2011	1367	19/**259.73**	36.56/**479.88**	11.16/**152.56**	4.52	6.1
2012	682	20.68/**141.04**	37.93/**258.68**	13/**88.66**	5.24	6.33
2013	1028	19.67/**202.21**	37.57/**386.22**	12/**123.36**	5.16	6.37
Spring Camelina Camelia						
2009	1531	18.87/**288.90**	41.08/**628.93**	11.06/**169.33**	4.41	6.18
2010	708	20.36/**144.15**	31.7/**224.44**	13.37/**94.66**	4.56	6.3
2011	982	19.74/**193.85**	34.5/**338.69**	12.06/**118.43**	4,43	6.1
2012	382	21,97/**83.93**	49.4/**188.71**	15.24/**58.22**	5.14	6.67
2013	483	20.87/**100.80**	33.35/**161.08**	15.1/**72.93**	4.36	6.38

Table 5

The energy yield of organic Camelia variety of Camelina sativa (L.) Crantz seeds based on Atwater specific factors[12] of energy seeds components – proteins, fats and carbohydrates (NARDI Fundulea – 2009 – 2013)

Year	DM yield (kg ha^{-1})	Energy yielding of seeds components			TOTAL (kJ ha^{-1})
		Protein (kJ ha^{-1})	Fat (kJ ha^{-1})	Carbohydrate (kJ ha^{-1})	
Autumn Camelina Camelia					
2009	1154	3606279	18619284	2122390	24347953
2010	869	2878386	9515917	1810379	14204682
2011	1367	4124253	17458034	2483067	24065354
2012	682	2239574	9410778	1443030	13093383
2013	1028	3210893	14050684	2007807	19269384
Average	*1020*	3211877	*13776160*	1973335	18961372
Spring Camelina Camelia					
2009	1531	4587443	22880473	2756015	30223932
2010	708	2288958	8165127	1540686	11994771
2011	982	3078144	12321542	1927567	17327253
2012	382	1332725	6865270	947589	9145584
2013	483	1600603	5860090	1187009	8647702
Average	*817.20*	2566650	11218501	1671773	15456923

The energy production of a crop depends also on Atwater specific factors of the crop energy components (Table 2). In our case study, the energy yield of the organic Camelina Camelia cultivated in autumn, ranged between 2239574–4124253 kJ ha^{-1} for proteins, 9342020–18619284 kJ ha^{-1} for fat and 1443030–2483067 kJ ha^{-1} for carbohydrate and in total, between 13093383–24347954 kJ ha^{-1}. The energy production of the spring Camelina Camelia ranged between 1332725–4587443 kJ ha^{-1} for proteins, 5860090–22880473 kJ ha^{-1} for fats, 947589–2756015 kJ ha^{-1} for carbohydrate and in total, between 8647702–30223932 kJ ha^{-1} (Table 5).

In each of 10 studied cases, the energy yield of organic Camelina Camelia seeds calculated based on Atwater specific factors, was higher than energy values of inputs, on average, 7.3 times at Camelina Camelia of autumn and 3.99 times at Camelina Camelia of spring. It means that, according to the definition of Bill Mollison[3] of sustainable system, in both sowing times, Camelina Camelia was a sustainable system, which confirms the first hypothesis (h1).

The energy yielding based on gross calorific value

The energy yield based on gross calorific value of a crop seeds depends on seeds yields in DM (kg ha^{-1}) and the gross calorific value (kJ/kg) of elemental components of seeds.

The gross calorific power of Camelina Camelia seeds (kJ) is equal with 3.2653 × 103 kJ/kg × seeds yield DM (Table 6), and it is ranged from simple to double, between 22269346–44636651 kJ ha^{-1} at Camelina Camelia of autumn, as well as from simple to quadruple, between 12473446–49991743 kJ ha^{-1} at Camelina Camelia of spring .

The energy yield estimated/calculated with Atwater specific factors is smaller than energy yield calculated with gross calorific value formula because the Atwater specific factors system uses only energy of the protein, fat and carbohydrate.

Compared to the solar radiation constant of about 40.694 billion kJ ha^{-1}/year[20] in the Fundulea area and growing season of Camelina Camelia, the energy production of Camelina Camelia is, like any other crop, “a drop in an ocean”.

Table 6

The gross calorific value of seeds of the Camelia variety of Camelina sativa (L,) Crantz (NARDI Fundulea 2009 – 2013)

Year	Seeds yield (kg ha^{-1}DM)	Gross calorific power (3.2653 × 10^3 kJ ha^{-1})
Camelina Camelia of autumn		
2009	1154	37681562
2010	869	28375457
2011	1367	44636651
2012	682	22269346
2013	1028	33567284
Average	1020	33306060
Camelina Camelia of spring		
2009	1531	49991743
2010	708	23118324
2011	982	32065246
2012	382	12473446
2013	483	15771399
Average	817.20	26684032

The sustainability indicators of organic Camelia Camelina sativa (L) Crantz (NARDI Fundulea 2009–2013)

The net energy (kJ ha^{-1}) and net energy rate are sustainability indicators. In case of Camelina Camelia, the net energy rate, in both methods of sustainability measurement, *(based on Atwater specific factors, respective on gross energy value)* ranged similar, from single to double, 4–8.4, respective 7.6– 16.2, at Camelina Camelia of autumn and from single to quintuple: 1.23–6.8, respective 2.23–11.92, at Camelina Camelia of spring.

Table 7

The sustainability indicators of Camelia Camelina sativa (L) Crantz based on Atwater specific factors and Gross calorific power (NARDI Fundulea 2009–2013)

Year	Sustainability indicators based on Atwater specific factors			Sustainability indicators based on gross calorific power		
	Net energy (kj ha^{-1})	Energy efficiency		Net energy (kj ha^{-1})	Energy efficiency	
		Rate	Significance		Rate	Significance
Camelina Camelia of autumn						
2009	21752171	8.379811	xx	35085779	13.51645	xx
2010	11608899	4.472215	x	25779674	9.93137	xx
2011	21469571	8.270942	xx	42040868	16.19583	xx
2012	10497600	4.044097	x	19673563	7.579048	x
2013	16673601	6.423347	x	30971501	11.93147	xx
Average	16365589	6.304684	x	30710277	11.83083	*xx*
Camelina Camelia of spring						
2009	26353856	6.809650	x	46121667	11.91751	xx
2010	8124695	2.099364	*NS*	19248248	4.97361	x
2011	13457177	3.477240	x	28195170	7.28466	x
2012	5275508	1.340395	*NS*	8603390	2.22305	*NS*
2013	4777626	1.234505	*NS*	11901323	3.07552	*NS*
Average	11586847	2.993959	x	22813956	5.89496	*x*

NS = Unsustainable

Also, according to F-values from ANOVA Tables 8 and 9, Camelina Camelia cultivated in autumn was sustainable each year, but in Camelina Camelia of spring, only in the 2009 and 2011 in case of sustainability estimation method with Atwater specific factors, respective in 2009, 2010 and 2011 in case of estimation method based on Gross calorific power. This means that hypothesis 2 *The energy produced of a system is significant more than energy consumed by it,* it is not confirmed always, but only if the net energy rate is greater than the statistic F-value.

Table 8

The one-way analysis of variance (ANOVA) of the Net energy rate at two sowing times of organic Camelia Camelina sativa (L.) Crantz, estimated on the base of Atwater specific factors (NARDI Fundulea, 2009–2013)

Source of variation	The sum of squares	Degrees of freedom	Mean Square	F-value	F-table	
					0.05	0.01
Total	112.24334	9	-			
Replication	33.260751	4	-			
Sowing time (St)	27.430856	1	27.43086	2.1284	7.708647	21.19769
Error	51.551736	4	12.88793			

Table 9

The one-way analysis of variance (ANOVA) of the Net energy rate at two sowing times of organic Camelia Camelina sativa (L.) Crantz, estimated on the base of gross calorific power *(NARDI Fundulea, 2009-2013)*

Source of variation	The sum of squares	Degrees of freedom	Mean Square	F-value	F-table	
					0.05	0.01
Total	280.7914	9	–			
Replication	85.3331	4	–			
Sowing time (St)	88.08916	1	88.08916	3.28173	7.708647	21.19769
Error	107.3691	4	26.84228			

CONCLUSIONS

1. The sustainability refers to systems and theirs lifetime energy production and consumption;

2. The sustainability is the feature of system to produce more energy than it consumes at establishment and its maintenance during lifetime;

3. The sustainability of system can be measure by formula:

Ss = ∑ Ep – ∑ Ec, in which **Ss** is Sustainability of the system; **Ep** – energy produced by the system (Outputs); **Ec** – energy consumed to set-up and maintain the system (Inputs) during its lifetime; **p** and **c** = 1 to n and **n** – number of types of energy produced, respective consumed by the system.

4. The energy yield of a system can be estimate by two methods, equally correct, but suitable of the analytical data, based on:

– the Atwater specific factors of the essential crops energy components: protein, fat and carbohydrate;

– the gross calorific value formula in case of the elemental energy components: carbon (C), hydrogen (H), sulphur (S), oxygen (O), Nitrogen (N), water(W), ash (A), etc.

5. The indicators of sustainability are:

– Net energy: difference of the energy produced (Outputs) and the energy consumed (Inputs) by system;

– Net energy (Efficiency) rate: the ratio of the net energy produced (Output) to the energy consumed (Inputs) by system;

6. The hypothesis that energy produced of a system is significant more than energy consumed by it, it is not confirmed always, but only if the net energy rate is greater than its the statistic F-value.

7. The sustainability measurement model based on energy balance is important, mainly in agriculture vegetal production, where energy yield is always higher than energy consumed, because it is produced in photosynthesis processes.

8. The cultivation of Camelia variety of Camelina sativa (L.) Crantz in organic system is sustainable if it produce, at least, of 2.13–3.28 times more energy than the one consumed in the cropping system.

REFERENCES

1. Jack Broughton (September 2024) Answer to Ion Toncea proposal at How sustainability can be measured, https://www.researchgate.net, Q&R 576 What is sustainability? How can we make sustainable development a reality? How sustainability can be measured?.
2. Annabel L. Mervil and Benice K. Watt (1973) – Agriculture Notebook No 74, Human Nutrition Research Branch,

Agricultural Research Service, United States Department of Agriculture.
3. Bill Mollison, David Holmgren, (May 26, 2016) – What is Permaculture, YouTube. Ecofilm; https://en.wikipedia.org/wiki/Sustainability measurement
4. Bell S. and Morse St. 2008. *Sustainability Indicators. Measuring the Immeasurable?* 2nd edn. London: Earthscan. ISBN 978-1-84407-299-6.
5. Teșu I. și Baghinsch V., Energia și Agricultura (1984) – Metodologie de calcul și analiză a eficienței energetie în agricultură, Editura Ceres, pp. 13 – 21, 243–245.
6. Toncea I. (September 2o24) – How sustainability can be measured?. https://www.researchgate.net, Q&R 575 What is sustainability? How can we make sustainable development a reality? How sustainability can be measured?
7. Toncea I. (2014) – The seed yield potential of camelia – first romanian cultivar of Camelina (*Camelina sativa* L. Crantz), Romanian agricultural research, No. 31, pp. 17–23.
8. Toncea I., Necseriu D., Prisecaru T., Balint L.-N., Ghilvacs M.-I., Popa M. (2013) – The seed's and oil composition of Camelia – first Romanian cultivar of Camelina *(Camelina sativa,* L. Crantz), *Romanian Biotechnological Letters*, Vol. 18, No. 5, pp. 8594–8602.
9. Toncea I., Campbell A., 1995, Sustenabilitatea – Teorie și Imperative, Probl. agrofit. teor. aplic. vol. XVII(l): 1–1, 2., Available in English in ResearchGate Q&R 575/2024 – What is sustainability? How can we make sustainable development a reality? How sustainability can be measured?
10. Wojciech, J.C., Pawłowski, J., Witczak, M., Walkowiak, M., (2016) – Comparison of methods for determining the calorific value of fuels obtained from wooden biomass, Ann. WULS – SGGW, For. and Wood Technol. 94.

Website references:
11. https://www.enel.com/company/stories/articles/2023/06/three-pillars-sustainability;
12. https://en.wikipedia.org/wiki/sustainability_measurement ;
13. https://www.fao.org/4/y5022e/y5022e04.htm
14. https://en.wikipedia.org/wiki/Energy_efficiency;
15. https://en.wikipedia.org/wiki/Kilowatt-hour#:~:text=The%20International%20System%20of%20
16. https://www.feedtables.com/content/rapeseed-whole;
17. https://www.google.com/search?q=calorific+value+of+diesel+in+kj%2Flitre&sca_esv=02c44965d6d4b280&sca_upv=1&sxsrf=ADLYWII5l8Z5xjO4O5vA4EYqP2fen6IkUw%3A1727278492729&ei=nC30Zq2aLNiN9u8PtvjY-Q&oq=calorific+value+of+diesel+per+litre&gs_lp ;
18. https://www.google.com/search?q=Calorific+value+of+Cu&oq=calorific+value+of+cu&gs_lcrp;
19. https://www.google.com/search?q=calorific+value+of+sulfur&sca_esv=1ddba70af590f790&sca_upv=1&sxsrf=ADLYWIJ4T1Qr8W7khzPXN13YG2NyAMixrg%3A1727337572738&ei=ZBT1ZunjLPGI9u8Pm9vxMQ&oq
20. https://www.google.com/search?q=Solar+radiation+potential+in+Romania&oq=Solar+radiation+potential+in+Romania+&gs_lcrp=EgZjaHJvbWUyBggAEEUYOTIHCAEQIRigATIHCAIQIRigATIHCAMQIRigAdIBCjQ3ODg4ajBqMTWoAgiwAgE&sourceid=chrome&ie=UTF-8 .