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Società Italiana per lo Studio delle Sostanze Grasse

The modern Oil Mill: extraction Efficiency, olive oil Quality, Diversification and Sustainability

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During the last 20 years, important transformations took place within the Italian sector of oil mill, and in particular:

- the number of **oil mills** diminished;

- most of oil mills are equipped with the **Centrifugation** system, at three or two phases;

- the activity of the **industrial sector of pomace oil** diminished, due, in particular, to the reduction of pomace oil consumption;

- that, forced some oil mills, having medium-large capacity, to change the **olive processing diagram** with the end to recover part of oil and stone fragments contained in the olive pomace.

To day, most of medium-high size oil mills carry out the following operations:

- **DOUBLE EXTRACTION** of **VIRGIN OLIVE OIL** from **OLIVE PASTE**

- **RECOVERY** of **STONE FRAGMENTS**

- **UTILIZATION** of **OIL MILL BY-PRODUCTS**

The preparation of **OLIVE PASTE** is carried out by :

the METALLIC CRUSHER at fixed HAMMERS

Olive paste **malaxation** is carried out by the large **mixers** in series and placed in vertical

Centrifugal decanter at 3-phases

Centrifugal decanter at 2-phases

Centrifugal decanter at 2-phases

Practical test of

DOUBLE EXTRACTION of **VIRGIN OLIVE OIL** from **OLIVE PASTE**

Results obtained in the double extraction of oil from olive paste (cv. **Coratina**) by centrifugal decanter at **three** phases in industrial oil mill of Puglia region.

(Oil 2nd Extr.: Eritrodiol + Uvaol = 4.7%)

(Source: L. Di Giovacchino et al., *RISG*, 68, 519-527, 1991)

H_2O %	OIL %	YIELD %		OLIVE POMACE		Oil Mill Wastewater		Oil lost *
		1st Extrac.	2nd Extrac.	H_2O %	OIL %	Dry Matt. %	OIL g/L	
45.2	**23.2**	**85.3**	**2.2**	**47.6**	**2.29**	**9.6**	**12.2**	**2.62**

* Value calculated and expressed as kg/100 kg olives

Results obtained in the double extraction of oil from olive paste (cv. **Coratina**) by centrifugal decanter at **two** phases in industrial oil mill of Puglia region.

(Oil 2nd Extr.: Eritrodiol + Uvaol = 9.8%)

(Source: L. Di Giovacchino et al., *RISG*, 79, 351-355, 2002)

H_2O %	OIL %	YIELD %		Olive Pomace 1st Extr.		Olive Pomace 2nd Extr.		Oil lost *
		1st Extr.	2nd Extr.	H_2O %	OIL %	H_2O %	OIL%	
48.4	**23.5**	**84.5**	**2.6**	**62.8**	**4.00**	**68.7**	**2.8**	**2.50**

* Value calculated and expressed as kg/100 kg olives

Results obtained in the double extraction of oil from olive paste (cv. **Coratina**) by the centrifugal decanter at **two** (first extraction) and **three** phases (second extraction) in an industrial oil mill of Puglia region.

(Oil 2nd Extr.: Eritrodiol + Uvaol = 8.5%)

(Source: L. Di Giovacchino et al., *E.J.L.S.T*, 119, 1600161, 2017)

H_2O %	OIL %	YIELD %		OLIVE POMACE		Oil Mill Wastewater		Oil lost *	Recoverd Stone *
		1st Extrac.	2nd Extrac.	H_2O %	OIL %	Dry Matt. %	OIL g/L		
50.5	**21.2**	**85.6**	**1.4**	**59.5**	**3.00**	**10.4**	**18.5**	**2.40**	**12.6**

* Value calculated and exprtessed as kg/100 kg olives

Oil yield and oil lost (in the by-products) in olive processing by the double centrifugation

100 kg olives = 21.2 kg of oil

Extracted Oil	kg	18.4	(18.1 + 0.3)
Oil in the Pomace	kg	1.3	
Oil in OMW	kg	1.1	
Oil in the Sludges	kg	0.3	

Average recovered income (oil and other by-products) for oil mill having a practical loading capacity of 100 t olives/day and equipped with decanters at 2 and 3-phases and a stoner machine.

RECOVERY of by-PRODUCTS	**Average amount/day**	**Value** (rough) (Euro/day)
Oil of 2nd Extraction (kg) (3-4 kg/t olives)	**300**	**900**
Olive stone fragments (t) (100-120 kg/t olives)	**12**	**1800**
Olive pomace (from 3-phases decanter) (t) (450 kg/t olives)	**45**	**675**
Olive Mill Wastewater (m^3) (0.45 m^3/t olives)	**50**	**175**

Price: oil 3 Euro/kg; Stones: 150 Euro/t; Wet pomace: 15 Euro/t; OMW: 3.5 Euro/m^3

RECOVERY

of

STONE FRAGMENTS

The biggest Italian oil mill located in Puglia region (year 2014). It is equipped with 16 centrifugal decanter (at 2 and 3-phases) having, each one, a theoretical loading capacity of 15 t / h of olive paste.

The stone fragments are recovered by a stoner machine and represent an important income of oil mill

The biggest Spanish oil mill located in Andalusia region (year 2017). It is equipped with 14 centrifugal decanter (at 2 phases) having, each one, a theoretical loading capacity of 15 t / h of olive paste.

Other large oil mill where the stone fragments are recovered from olive pomace

Spanish oil mill

The LIGNIN is a complex organic polymer constituted by phenolic compounds. The polymeric structure is three-dimensional (3-D) and formed by phenylpropane units. In particular, the polymeric units are constituted by 3 different monomers:

1) alcohol *p*-coumaric; (alcohol-4-hydroxycinnamic)

2) alcohol coniferilic (alcohol 4-hydroxy-3-methoxycinnamic);

3) alcohol synaptic (alcohol 4-hydroxy-3,5-dimethoxycinnamic).

Average results of some characteristics of stone fragments separated from olive pomace obtained in olive processing by decanter at 3 and 2 phases

(Source: M.G. Di Serio et al., *RISG*, 88, 111-117, 2011)

Olive pomace (obtained from)	**Characteristics of stone fragments**			
	Moisture %	**Oil** %	**Ash** %	**Calorific power** (Kcal/kg)
Decanter at 3 phases	**19.5**	**0.49**	**0.32**	**4134**
Decanter at 2 phases	**20.8**	**0.27**	**0.39**	**4100**

Composition (% on dry matter) of olive stone fragments obtained after separation from olive paste by a partial de-stoner machine.

(Source: A. Leone et al., *Biomass and Bioenergy*, 81, 108-116, 2015)

Parameter	Value	Parameter	Value
Moisture	22.0 %	**Carbon**	49.6 %
Oil	0.44 %	**Hydrogen**	7.05 %
Ash	0.21 %	**Oxygen**	43.1 %
High Calorific value	20.0 MJ/kg	**Nitrogen**	0.044 %
Low Calorific value	18.1 MJ/kg	**Sulphur**	0.023 %

If isn't possible to sell **OLIVE POMACE** to the industry of pomace oil, it is

RATIONAL and **ADVANTAGEOUS**

to **USE** it by

the **controlled spreading** on cultivated soil

Results obtained in olive trees cultivation (cv. Leccino) on soil treated, for 4 consecutive years, with 50 t/ha of fresh olive pomace from a 3-phases decanter.

(Source: Nasini et al., *Agriculture, Ecosystem and Environment*, 164, 292-297, 2013)

Parameters	1st Year		2nd Year		3rd Year		4th Year	
	Control	50 t/ha	Control	50 t/ha	Control	50 t/ha	Control	50 t/ha
Olive production (kg olives/tree)	5.8	7.2	8.0	10.0	11.8	16.0	17.8	22.0
Productive efficiency (kg olives/m^3 foliage)	0.50	0.60	0.65	0.90	0.82	0.95	1.25	2.35

RATIONAL UTILIZATION

of

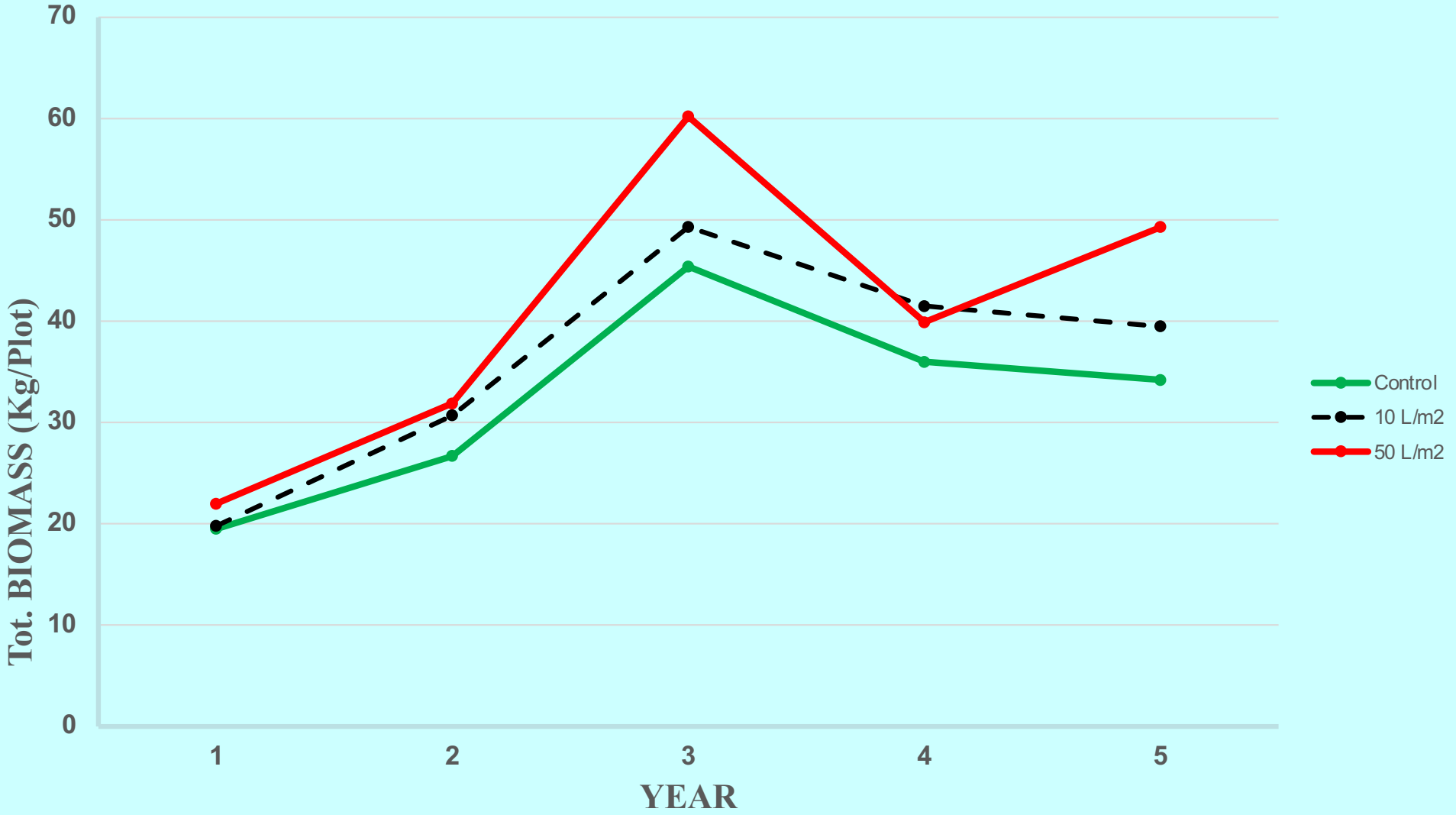
OIL MILL WASTEWATER

Amount (kg/ha) of organic and mineral matter supplied to the soil by spreading the maximum volume of OMW permitted from the Italian law 574/1996.

Fertilizer elements	Oil Mill Wastewater (OMW) obtained by	
	Pressing system 50 m^3/ha	3-phases Centrifugation system 80 m^3/ha
Dry organic matter (kg)	4000 – 7000	3000 – 6000
Nitrogen (kg, as element)	30 – 50	25 – 50
Phosphorus (kg, as element)	15 – 30	15 – 30
Potassium (kg, as element)	100 – 200	80 – 160

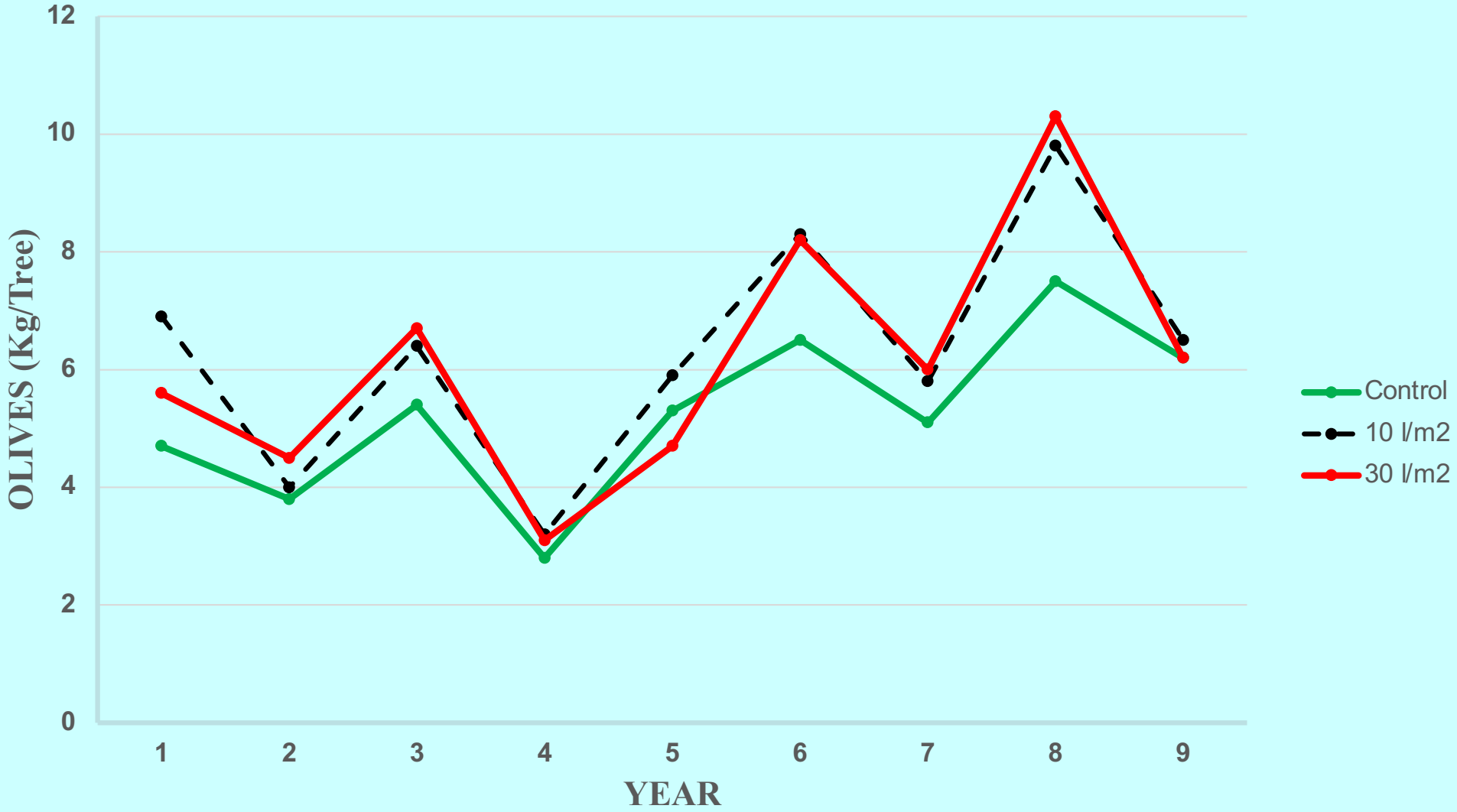
Results obtained in the **maize** cultivation (**5** consecutive years) on soil treated with oil mill wastewater (**OMW**).

(Source: L. Di Giovacchino et al., *Agric. Mediterranea*, 131, 33-41, 2001)



Quantitative results obtained (kg olives/tree) in **olive tree** cultivation (**9** consecutive years) on **olive orchard** treated with different amount of oil mill wastewater (**OMW**)

(Source: B. Lanza et al., *Comm. in Soil Science and Plant Anal*., 48, 20, 2420-2433, 2017)



Supply of organic dry matter and fertilizer elements to soil cultivated with **olive** trees and treated with different amount of **OMW**

(Source: B. Lanza et al., *Comm. in Soil Science and Plant Anal*., 48, 20, 2420-2433, 2017)

Fertilizer Elements	**Control**	**Oil Mill Wastewater spread on soil**	
		10 L/m^2 (100 m^3/ha)	30 L/m^2 (300 m^3/ha)
Organic dry matter (kg/ha)	---	**5920**	**17760**
Nitrogen (kg/ha)	**46 + 25**	**23 + 12 + 50**	**150**
Phosphorous (kg/ha)	**50**	**25 + 15**	**45**
Potassium (kg/ha)	**100**	**50 + 160**	**480**

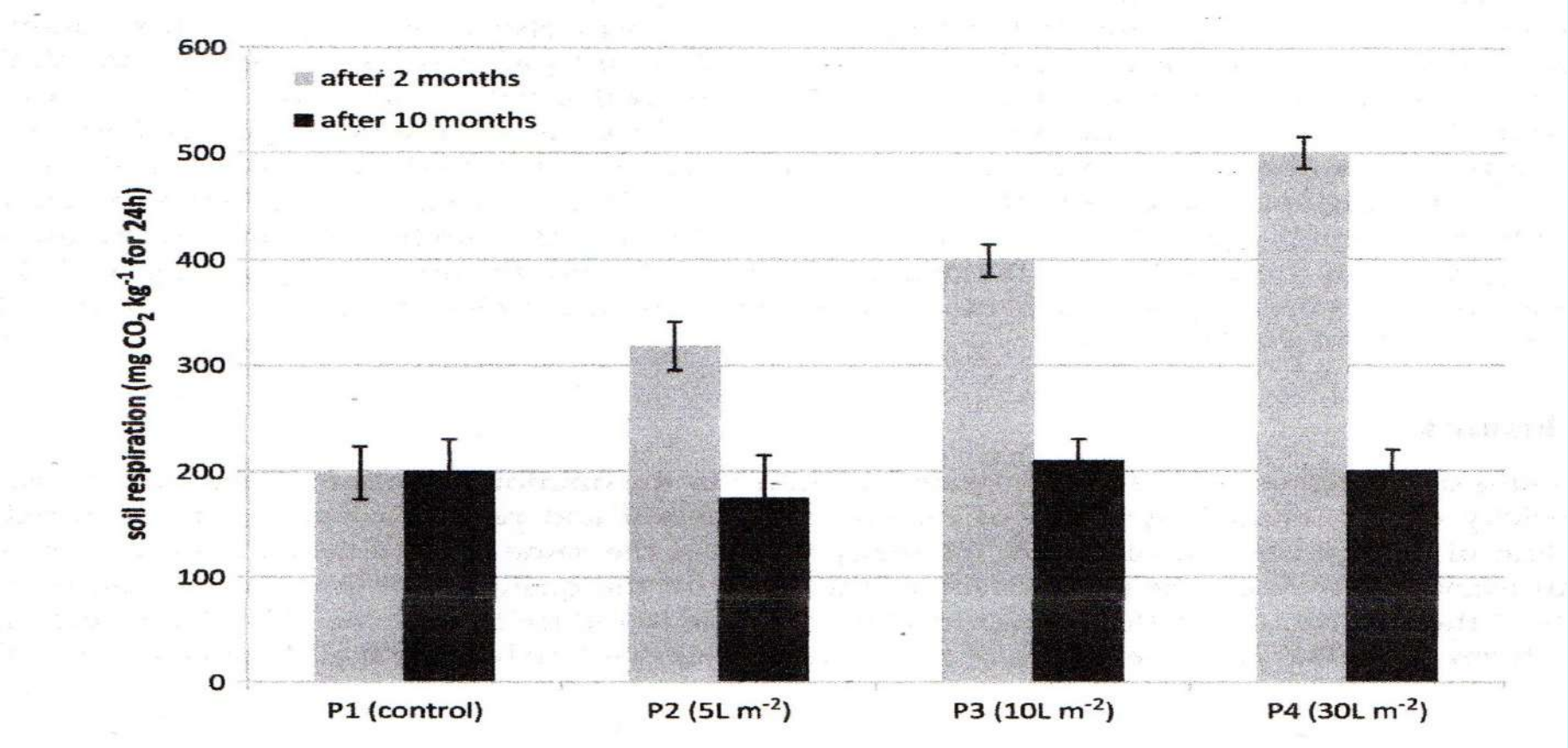
Chemical and micro-biological characteristics of soil cultivated with olive trees and treated for 9 consecutive years with OMW from 3-phases decanter

(Source: B. Lanza et al., *Soil Sc. and Plant Anal*., 48, 20, 2420-2433, 2017)

Determinations	Control	Oil Mill Wastewater (OMW) spread		
		5 L / m²	10 L / m² *	30 L / m² **
Chemical characteristics				
pH	7.7	7.8	7.7	7.8
Organic matter (g/100 g)	1.77	1.88	2.11	2.18
Total nitrogen (g/100 g)	0.11	0.12	0.12	0.13
Reducing substances (mg/100 g)	0.12	0.25	0.30	0.42
Micro-biological characteristics				
Total microflora (CFU/g)	3.0×10^8	4.5×10^9	5.4×10^9	5.9×10^9
Yeast (CFU/g)	5.0×10^5	1.7×10^7	2.0×10^7	2.7×10^7

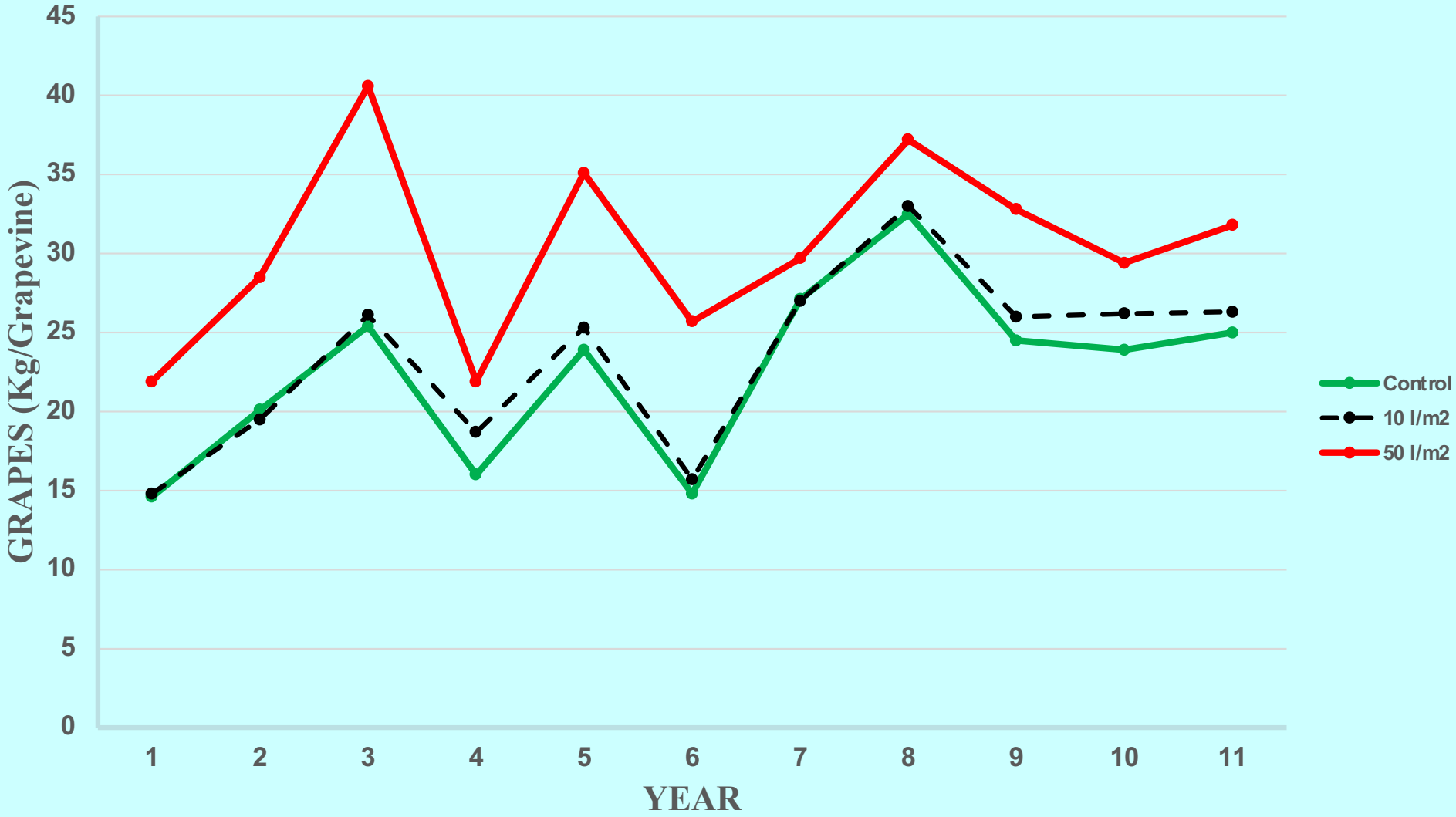
Respiratory activity of soil cultivated with olive trees, two and ten months after the spreading of different amount of OMW.

(Source: B. Lanza et al., *Soil Sc. and Plant Anal*., 48, 20, 2420-2433, 2017)



Results obtained in the **grapevine** cultivation (**11** consecutive years) on soil treated with oil mill wastewater (**OMW**)

(Source: B. Lanza et al., *Water Air Soil Pollut.*, 231, 86, 2020)



Supply of organic dry matter and fertilizer elements to soil cultivated with **grapevine** and treated with different amount of **OMW**

(Source: B. Lanza et al., *Water Air Soil Pollut*., 231:86, 2020)

Fertilizer Elements	**Control**	**Oil Mill Wastewater spread on soil**	
		10 L/m^2 (100 m^3/ha)	50 L/m^2 (500 m^3/ha)
Organic dry matter (kg/ha)	**---**	**4880**	**24400**
Nitrogen (kg/ha)	**46 + 25**	**23 + 12 + 40**	**200**
Phosphorous (kg/ha)	**50**	**25 + 20**	**100**
Potassium (kg/ha)	**100**	**50 + 140**	**700**

Characteristics of soil cultivated with **grapevine** after **11** consecutive years of treatment with different amount of **OMW**.

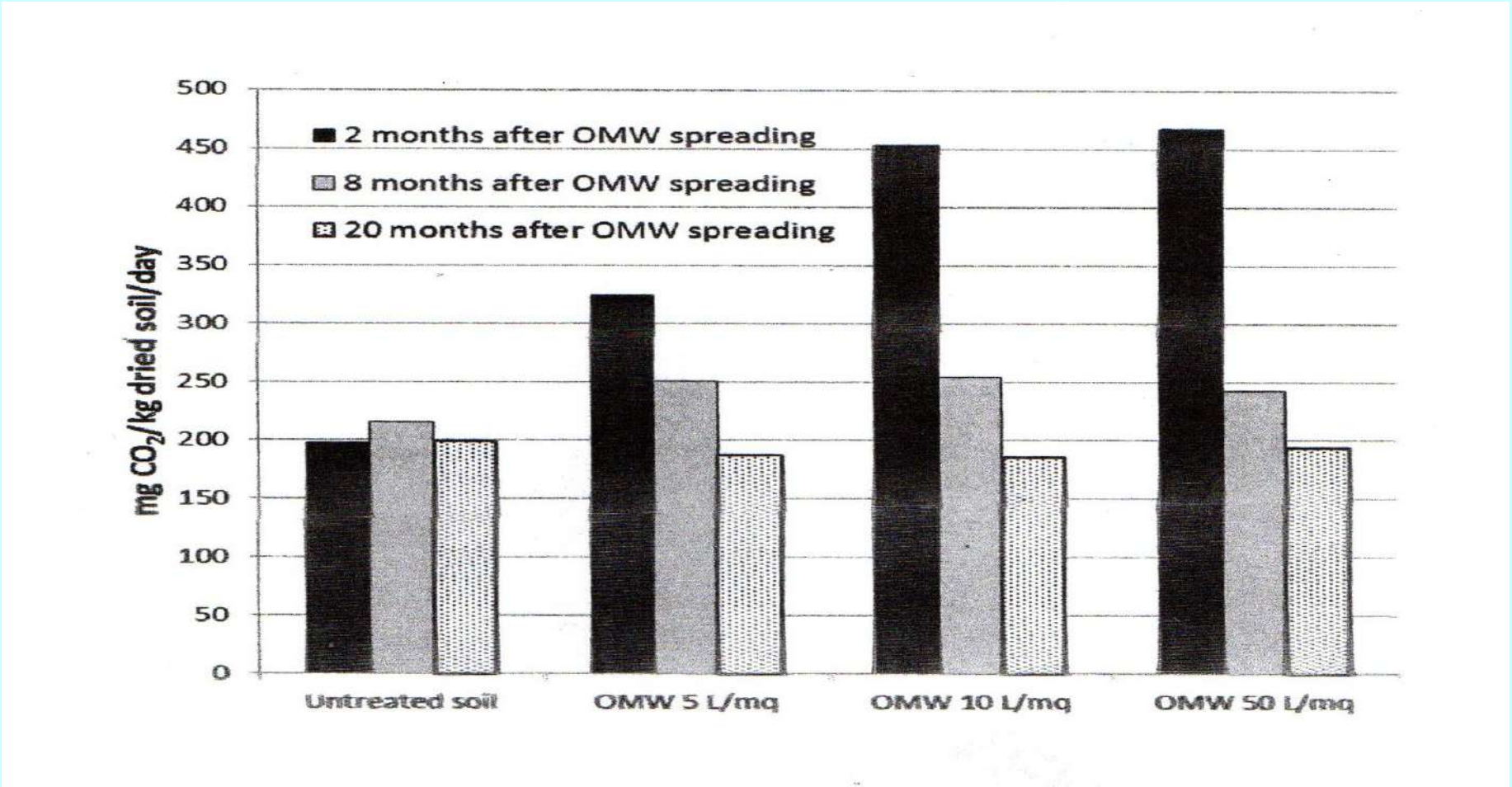
(Source: B. Lanza et al., *Water Air Soil Pollut*., 231.86, 2020)

*Partially fertilized plots; **Not fertilized plots.

Determinations	**Control**	**Oil Mill Wastewater (OMW) spread**		
		5 L/m²	**10 L/m² ***	**50 L/m² ****
pH	**7.96**	**7.94**	**7.93**	**8.04**
Organic carbon (%)	**0.94**	**0.97**	**1.00**	**1.13**
Organic nitrogen (%)	**0.10**	**0.11**	**0.11**	**0.13**
Reducing substances (mg/100 g, as caffeic acid)	**0.17**	**0.17**	**0.21**	**0.65**

Respiratory activity of soil cultivated with **grapevine**, two, heigt and twenty months after the spreading of different amount of **OMW**.

(Source: B. Lanza et al., *Water Air Soil Pollut*., 231:86, 2020)



CONCLUSIONS

- The described operations represent an effective example of **sustainable agriculture** and **circular economy**, because they help:

- to increase the **oil yield,** with economic benefit for oil mill;

- to recover the **stone fragments** to use as green fuel, because obtained from a **renewable source of energy**;

- to supply **organic and mineral substances** to cultivated soil, avoiding, or reducing, the use of chemical fertilizers, and improving the chemical and microbiological characteristics of the soil.

THANKS

for

YOUR ATTENTION