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Evaluating the agronomic properties of olive wastewaters digestate: Application and effect on wheat growth

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Abstract

Anaerobic digestion is an effective method for biowaste valorization. The digestate generated after the digestion process can be effectively utilized as a mineral fertilizer due to its high nutrient contents. The objective of the present work was to characterize the raw digestate obtained from an anaerobic digester of olive mill wastewaters (OMWs) in order to investigate its chemical and agronomic properties, and to evaluate the effect of its application on wheat culture. The effect of varied concentrations of the raw digestate was evaluated on wheat growth. The obtained results showed that the germination index and the soft wheat yield were significantly higher in the Tr3 treatment as compared to other three treatments. The number of leaves, the number of thalli and the height of main stem were also significantly higher in the Tr3 treatment as compared to other treatments. These results indicate that the effect of digestate in improving the growth and development of wheat is positive and it can be substituted for commercial fertilizer.

Keywords: Commercial poultry, Cellobacterin-T probiotic, Enzyme, Diet, Metabolism

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1. Introduction

Anaerobic digestion can be effectively used for waste treatment due to its advantages of reduction of toxicants and good energy recovery. **[**1**,** 2**]**. The process of anaerobic degradation not only converts biowaste into renewable energy (biogas) and digestate **[**3**]** but also significantly reduces pathogens and pollutants present in the biowastes **[**4**]**. The digestate can be used as a soil biofertilizer because it improves the chemical and biological properties of soil and it can have a positive influence on its fertilization. It is also considered as a good source of potassium and phosphorus **[**5-7**]**.

On the other hand, the utilization of inorganic fertilizers and synthetic pesticides has a negative effect on the environment, human health, soil quality and fertility **[**8, 9**]**. The digestate or compost are very important to improve soil productivity **[**10**]**, because the nutrients from organic matter in the digester remain in the liquid digestate after anaerobic digestion process **[**11**,**12**,** 13**]**. If properly utilized, the digestate nutrients can be used a potential substitute of mineral fertilizers [14-17**]**.

The aim of this work was to make a complete physicochemical characterization of the raw anaerobic digestate being released from olive mill waste waters (OMWWs) in order to determine its use as a potential fertilizer for wheat development.

2. Material and Methods

2.1. Anaerobic digestate and Soil chemical analysis

Digestate was collected from a semi continuous reactor digesting olive mill waste waters (OMWWs) and working in batch mode. The raw digestate contained NH_4 (249,12mg/L), pH (7.4), EC (6.15ms/cm), HCO_3 (29,76), Mg (148.8mg/L), Na (690mg/L), NO_3 (104.66mg/L), SO_4 (13.68mg/L), Ca (360mg/L), K (97.5mg/L) and Cl (994mg/L).

The soil used was sampled from the 40 cm to 60cm layer from the university grounds. The collected soil was a sandy basic clay having low organic matter. The soil contained P_2O_5 (0.48 mg/g), organic matter (1.14%), K_2O (0.128 mg/g), pH (7.4), $CaCO_3$ (47%), Mg (1.28 mg/g) and Na (0.26 mg/g). Table 1 shows the granulometry of soil used.

Table 1: Soil granulometry

Granulometry	Value
Clay (%)	3.8
Fine silt (%)	1.9
Coarse silt (%)	0.5
Fine sand (%)	35.6
Coarse sand (%)	58.8

2.2 Experimental description

The experiment was carried out in a greenhouse using a completely randomized block design with four repetitions. Four fertilization treatments were tested including: no fertilization, fertilization by diluted digestate and the raw digestate. Different solutions of raw digestate obtained by diluting by water as follows: Te (witness), Tr_1 (50% digestate), Tr_2 (75% digestate) and Tr_3 (100% Digestate). These treatments were used to evaluate wheat growth in order to determine the optimal treatment for best culture growth. After each month, the number of leaves, the number of thalls per foot and the height of the main stem were, easured in order to evaluate the effect of anaerobic digestate on the wheat growth.

$$\text{Germination index (\%)} = \frac{\text{Final number of seeds that germinated}}{\text{Number of initial seeds}} * 100$$

Soft wheat yield **(g)** = number of ears /m^2 × Number of grains/ear × weight of 1000 grains

2.3 Statistical analysis

The analysis of the variance (ANOVA) was used to determine the effect of time and different treatment on the Growth and development of soft wheat. The Tukey-Kramer test was used to compare between the different treatments. The number of leaves, the number of thalls per foot, the height of the main stem and the soft wheat yield were also recorded.

3. Results and Discussion

3.1. Analysis of variance with repeated measurement over time

The analysis of repeated variance over time shows a significant effect of time, treatment and their interactions on the number of leaves and the height of the main stem. It indicates that there is a significant effect of treatment and time for the number of leaves and main stem height, while for the amount of thallium per individual there is a significant effect of treatment only.

3.2. Growth and development of soft wheat

3.2.1. Number of leaves per foot

The number of leaves varies significantly between treatments (F=86.7; dF=3; P<0.0001). It was significantly higher in the Tr3 treatment than in the others (figure 1). It was significantly lower in the control treatment and the Tr1 treatment. These results indicated the effect of digestate in improving the growth and development of wheat due to its richness in nutrients. In a previous study, a positive effect of digestate on a wheat crop has already been observed [19]. Another study conducted to evaluate the effect of digestate and fly ash applications on soil functional properties have shown positive response [18].

3.2.2. Number of thalls per foot

Figure 2 shows the effect of the various treatments on the number of thalls per foot. The number of thalls produced per individual differs significantly between treatments (F=63.8; dF=3; P<0.0001). It is significantly greater in the Tr3 treatment than in the others. However, it is significantly lower in the two treatments (control and Tr1) which do not differ between them, so the production of thalls per foot does not vary with time.

3.2.3. Height of main stem

The comparison between the pairs of treatments was performed by the Tukey-Kramer test. Different letters on the graph mean that the difference between treatments is significant (P<0.0001). As indicated in the figure 3, the height of the main stem varies significantly between treatments (F = 9.4; dF = 3; P < 0.0001). It was significantly greater in the Tr3 treatment than in the other three treatments (in which it did not differ significantly).

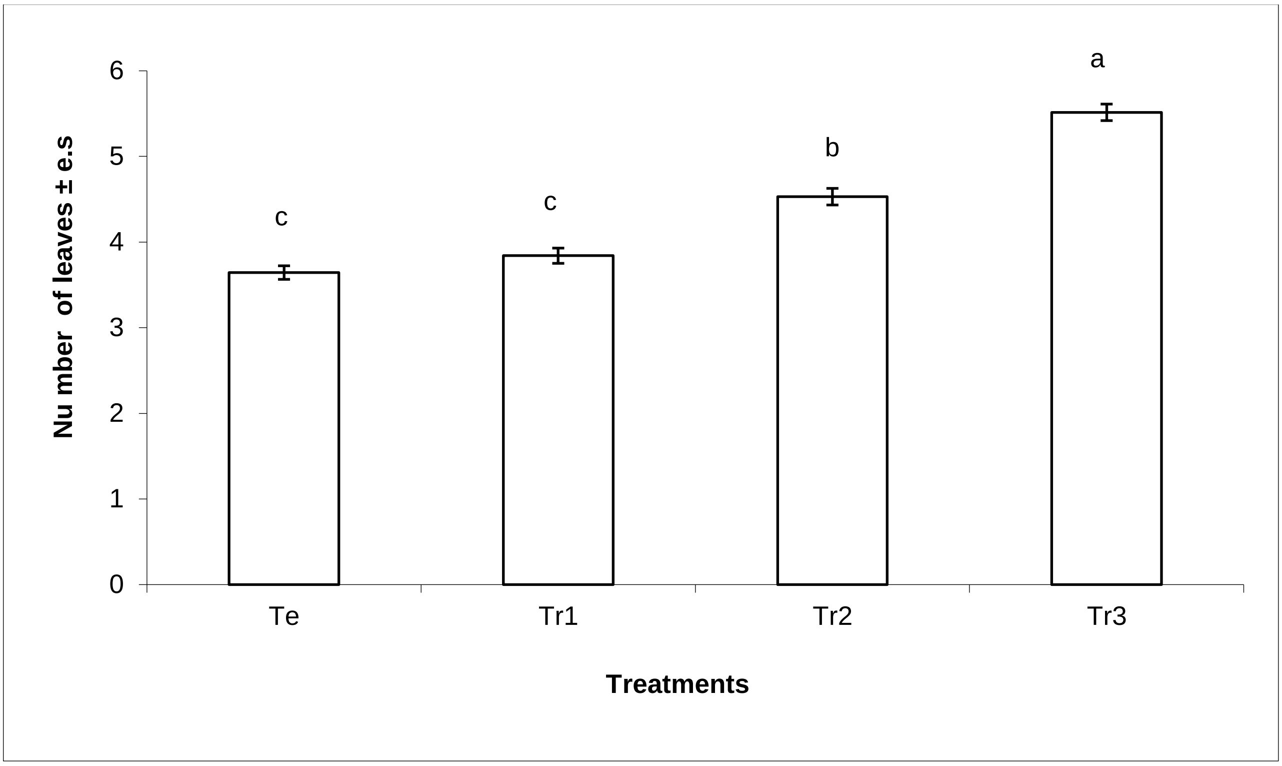

Figure 1: The effect of different treatments on the number of green leaves

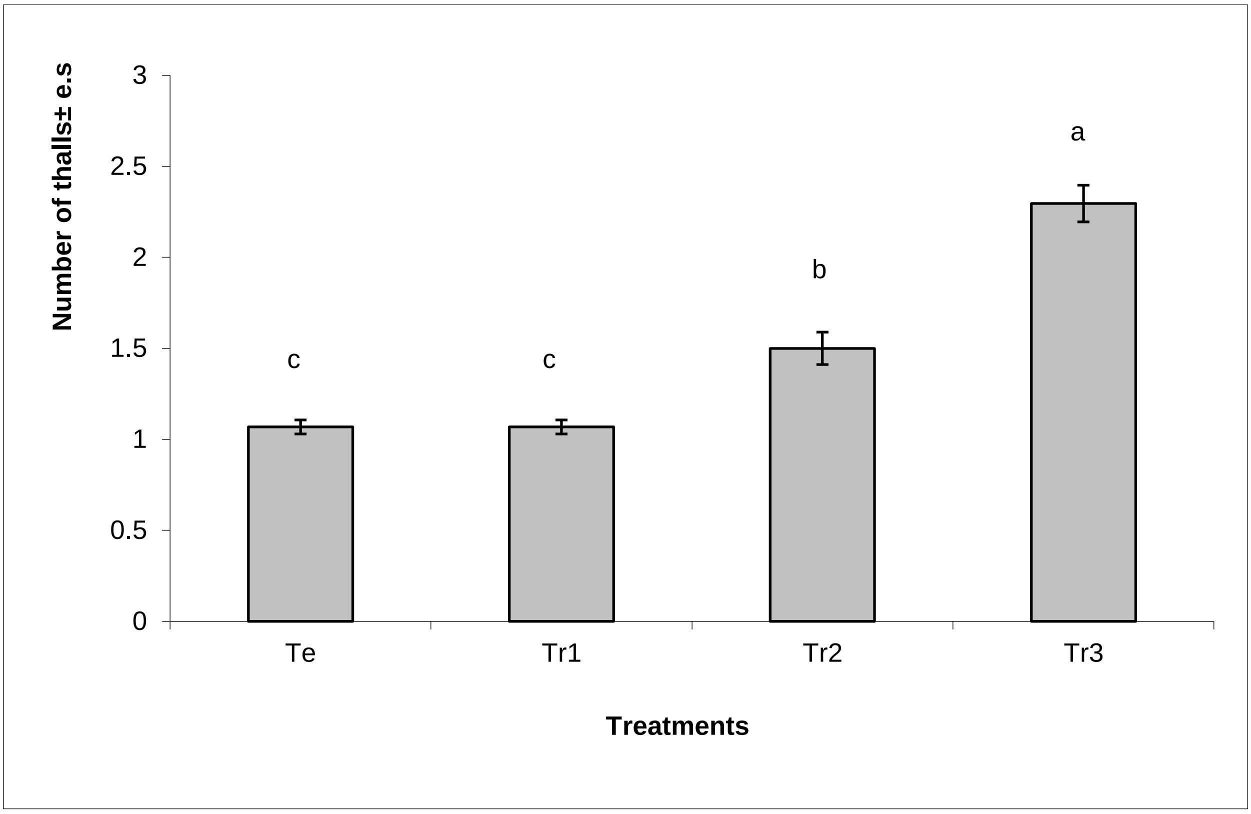

Figure 2: The effect of different treatments on the number of thalls per foot.

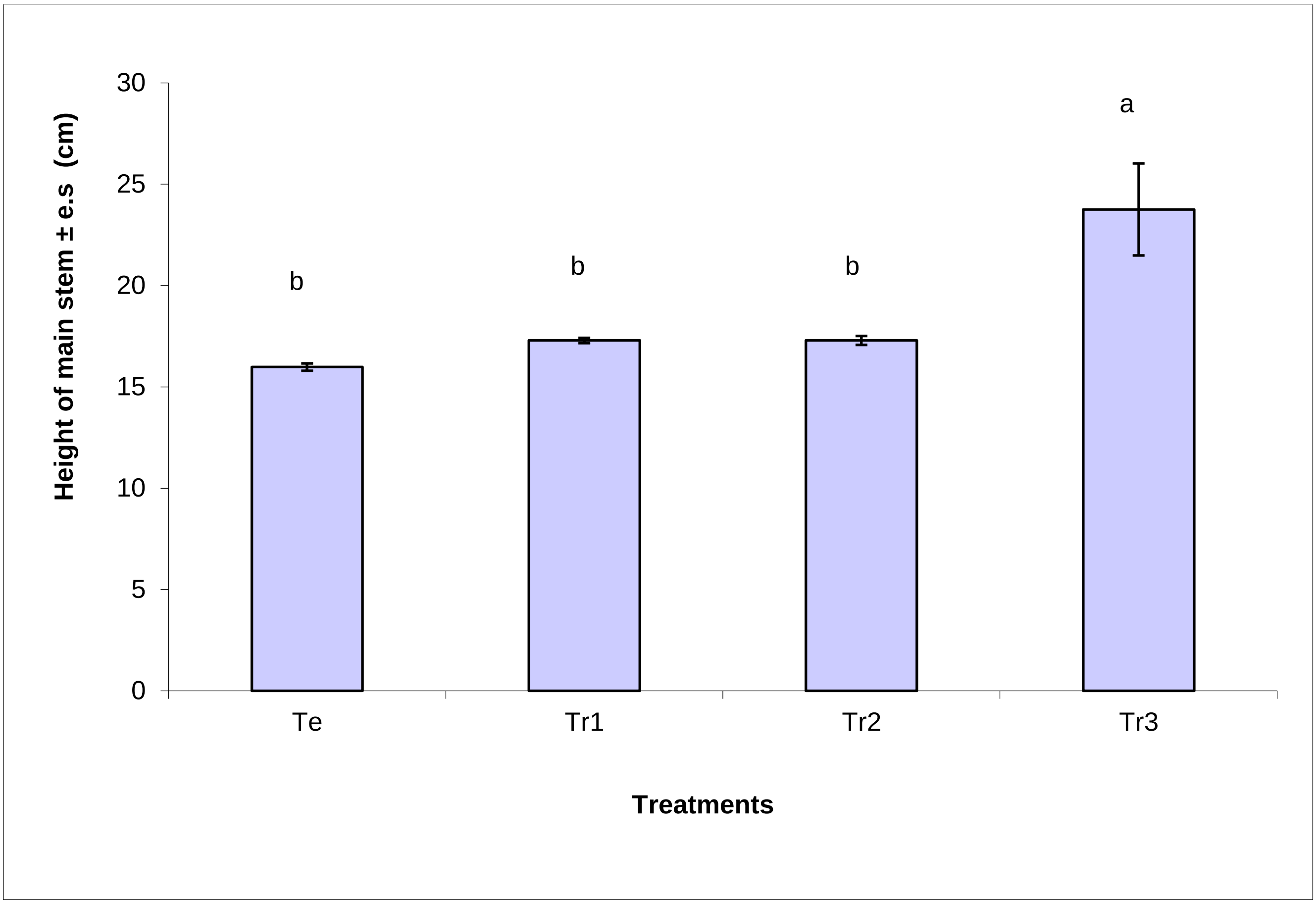

Figure 3: The effect of different treatments on the Height of main stem

Table 2: Soft wheat yield analysis

	ANOVA			Average				Average Comparison
	F	*dF*	*P*	Te	Tr1	Tr2	Tr3	
number of ears /m²	1.57	3	0.2476	283,5 ± 6.5	277 ± 7.5	290 ± 0,0	290 ± 0.0	T_e^a Tr_1^a Tr_2^a Tr_3^a
Number of grains/ear	19.79	3	<0.0001	18.0 1.7	18.3 ± 2.0	25.8 ± 0.9	35.3 ± 2.3	T_e^c Tr_1^{bc} Tr_2^b Tr_3^a
weight of 1000 grains (g)	5.44	3	0.0136	46.1 0.7	49.4 ± 0.9	45.1 ± 1.5	49.8 ± 0.5	T_e^{cba} Tr_1^{ba} Tr_2^c Tr_3^a
Soft wheat yield(g)	20.6	3	<0.0001	234028 ± 21303	250287 ± 29829	336452 ± 16375	509983 ± 38635	T_e^b Tr_1^b Tr_2^b Tr_3^a

3.3. Soft wheat yield analysis

Table 2 presents the results of the analysis of variance on the comparison between treatments of number of ears/m², number of kernels per ear, 1000 kernel weight and kernel yield. The comparison between treatment pairs was analyzed by the Tukey-Kramer test. Different letters in the table mean that the difference between treatments was significant (P<0.0001).

The number of ears produced per plant was significantly invariant between treatments. The number of grains produced per ear was significantly variable between treatments. It was significantly higher in the Tr3 treatment but lower in the Te and Tr1 treatments. The weight of grains produced was significantly different between treatments. The grains produced by the plants in the Tr3 and Tr1 treatments were significantly heavier than those obtained in the Tr2 treatment. The grain yield of wheat and the product of the number of ears per m^2, the number of grains per ear and the weight of one thousand grains vary significantly between treatments. It was significantly better in the Tr3 treatment than in the other three treatments.

4. Conclusions

The raw digestate generated from the anaerobic digestion of olive mill wastewaters has been used as an alternative to inorganic fertilizer. The results of the analysis showed that the digestate can have a very interesting fertilizing effect due to the presence of potassium and nitrogen with high concentrations. Our research revealed the potential of the use of different concentrations of digestate for improving the growth and development of wheat. The soft wheat yield was significantly better in the Tr3 treatment than in the other treatments. Thus, the digestate can be substituted to commercial fertilizer and it is positively recommended as a source of nutrients to improve wheat growth and soil fertility.

Authors' contributions

FE, FZ, HL and AE performed the experiments; FE, MR and YZ designed the experiments; FE, RH and RL wrote this manuscript. All authors read and approved the final manuscript.

Competing interests

We have no competing interests.

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Availability of data and materials

All data generated and analyzed during this study are included in this manuscript.

Consent for publication

All authors have approved to submit this work to Chemical and Biological Technologies in Agriculture. They declare that there is no conflict of interest in relation to the submission of the article.

Ethics approval and consent to participate

Not applicable.

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References

[1] H.W. Yen and D.E. Brune. (2007). Anaerobic codigestion of algal sludge and waste paper to produce methane. Bioresource Technology. 98 : 130-134.

[2] G. De Gioannis, A. Muntoni, A. Polehini, R. Pomi and D. Spiga. (2017). Energy recovery from one- and two-stage anaerobic digestion of food waste. Waste Management. 68 : 595-602.

[3] K. Risberg, H. Cederlund, M. Pell, V. Arthurso and A. Schnürer. (2017). Comparative characterization of digestate versus pig slurry and cow manure – chemical composition and effects on soil microbial activity. Waste Management. 61 : 529–538.

[4] V. Orzi, B. Scaglia, S. Lonati, C. Riva, G. Boccasile, G.L. Alborali and F. Adani. (2015). The role of biological processes in reducing both odour impact and pathogen content during mesophilic anaerobic digestion. Science of the Total Environment. 526 : 116–126.

[5] V. Orzi, E. Cadena, G. Imporzano, A. Artola, E. Davoli, M. Crivelli and F. Adani. (2010). Potential odour emission measurement in organic fraction of municipal solid waste during anaerobic digestion: relationship with process and biological stability parameters. Bioresource Technology. 101 : 7330–7337.

[6] A. Slepetiene, J. Volungevicius, L. Jurgutis, K. Liaudanskiene, I. Amaleviciute-Volunge, J. Slepetys and J. Ceseviciene. (2020). The potential of digestate as a biofertilizer in eroded soils of Lithuania. Waste Management. 102 : 441–451.

[7] F. Tambone, B. Scaglia, G. D'Imporzano, A. Schievano, V. Orzi, S.Salati and F. Adani. (2010). Assessing amendment and fertilizing properties of digestates from anaerobic digestion through a comparative study with digested sludge and compost. Chemosphere. 815 : 577–583.

[8] K. Möller and T. Müller. (2012). Effect of anaerobic digestion on digestate nutrient availability and crop growth: a review. Engineering in Life Sciences. 3 : 242–257.

[9] M.W. Geraldin, J. Ernest and M. Ega. (2020). Phytochemical activity and role of botanical pesticides in pest management for sustainable agricultural crop production. Scientific African. 7 : 22-39.

[10] A. Das, R. Lal, D. Patel, R. Idapuganti, S.V. Jayanta Layek, P.K. Ngachan, J.B. Ghosh and K. Manoj. (2014). Effects of tillage and biomass on soil quality and productivity of low land rice cultivation by small-scale farmers in North Eastern India. Soil and Tillage Research. 143 : 50–58.

[11] M. Diacono and F. Montemurro. (2010). Long-term effects of organic amendments on soil fertility. A review. Agronomy for Sustainable Development. 30 : 401–422.

[12] B. Stürmer, E. Pfundtner and F.S. Kirchmeyr. (2020). Uschnig. Legal requirements for digestate as fertilizer in Austria and the European Union compared to actual technical parameters. Journal of Environmental Management. 253 : 1-9.

[13] A. Albuquerque, C. De la Fuente, A. Ferrer-Costa, L. Carrasco and J. M. Cegarra. (2012). Assessment of the fertiliser potential of digestates from farm and agroindustrial residues. Biomass Bioenergy. 40: 181–189.

[14] E. Uggetti, B. Sialve, E. Latrille and J.P. Steyer. (2014). Anaerobic digestate as substrate for microalgae culture: the role of ammonium concentration on the microalgae productivity. Bioresource Technology. 152 : 437–443.

[15] C. Vaneeckhaute, E. Meers, E. Michels, J. Buysse and F.M.G. Tack. (2013). Ecological and economic benefits of the application of bio-based mineral fertilizers in modern agriculture. Biomass Bioenergy. 49 : 239-248.

[16] Q. Ning, L. Chen, C. Zhang, M. Donghao, L. Daming, X. Han, Z. Cai, S. Huang and J. Zhang. (2021). Saprotrophic fungal communities in arable soils are strongly associated with soil fertility and stoichiometry. Applied Soil Ecology. 129 : 38-43.

[17] S.K. Prajapati, P. Kumar, A. Malik and V.K. Vijay. (2014). Bioconversion of algae to methane and subsequent utilization of digestate for algae cultivation: a closed loop bioenergy generation process. Bioresource Technology. 158 : 174–180.

[18] C. Riva, V. Orzi, M. Carozzi, M. Acutis, G. Boccasile, S. Lonati, F. Tambone, G. D'Imporzano and F. Adani. (2016). Short-term experiments in using digestate products as substitutes for mineral (N) fertilizer: Agronomic performance, odours, and ammonia emission impacts. Science of the Total Environment. 547 : 206–214.