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COMPARATIVE RESEARCH ON WOOL PELLETS REGARDING SOME PHYSICO-CHEMICAL CHARACTERISTICS FOR THEIR USE IN AGRICULTURE

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Abstract: At EU level, the situation of wool waste is regulated by EC Regulation 1069 (2009) and EU Regulation 142 (2011) which define wool as an animal by–product that has to be landfilled as a category 3 solid waste which means it is classified as low risk. Since it is impossible to avoid generating wool waste, reuse and recycling remain the best solutions for managing this keratinous waste. In agriculture, both raw wool and in different forms – pellets or hydrolysate from wool – can be used as organic fertiliser. Some physico–chemical properties of wool pellets have been studied in comparison, such as: water absorption and bulk density
Keywords: wool waste, fertilizer, pellets, physico–chemical characteristics

1. INTRODUCTION

The annual production of wool waste is estimated at around 317 thousand tonnes per year, which is mainly the amount of low–quality wool that cannot be used for textiles. Thus large quantities of raw wool that cannot be traded, have turned into problematic waste, which is dumped in landfills, buried or burned directly on fields, causing air and soil pollution when the amount of wool is not carefully controlled (Kumawat, T.K., 2018; Marchelli, F. et al., 2021). These figures show that the recovery of wool waste is of great economic importance, while also solving the environmental problems it generates.

The current situation of wool waste is regulated at European level by Regulation EC 1069 (2009) and Regulation EU 142 (2011) implementing Regulation EC 1069 (2009) (2011). These Regulations: (1) define wool as an animal by–product that must be landfilled as solid waste unless it is directed to the textile supply chain, and (2) set rules for the management of raw wool and hair, which are considered as category 3 animal by–products (ABP), meaning that they are classified as low risk.

In order to combat this pollution and to use this large amount of waste as a resource, it has been proposed over the years to use wool waste for numerous applications such as insulation (Cai, Z. et al., 2021), building materials (Merli, F. et al., 2020), adsorbents (El–Geundi, M.S.,1997) and composite materials (Remadevi, R., et al., 2020). Because wool is a good source of nitrogen (Vončina and Mihelič 2013) due to its amide clusters and possesses a moisture holding capacity of 3.5 times its weight (Ordiales, E., et al., 2016), one way to dispose of wool waste is to decompose it together with other agricultural by–products and use it in agriculture as a fertilizer. The use of raw wool as an organic fertiliser is based on its ability to degrade slowly when buried in the soil and to release essential crop nutrients such as nitrogen (N) and sulphur (S).

The degradation of buried wool is evident in terms of months: keratin macromolecules start to break down after 4 weeks, and under hydrophilic conditions, weight loss is 33% in three months (Arshad et al., 2014). These numbers prove that wool can act as an excellent slow–release organic fertilizer. It also acts as a soil amendment due to its fibrous structure and water–holding capacity.

Wool pellets are 100% natural and biodegradable materials, commonly applied to the soil for nutrient fertilization, which have no negative impact on the environment: no soil pollution, no water contamination and no soil degradation, in addition to maintaining biodiversity, as well as preventing the infiltration of toxic substances into groundwater or surface soil (Maria și Pacurar, 2015).

Another way to use wool as a fertilizer is by using sheep wool hydrolysate (a substance produced by hydrolysis) which can also improve plant growth conditions by increasing the content of essential elements N, C and P in the soil (Vončina și Mihelič 2013). Applied hydrolyzed wool also acts as a chelating agent for available soil micronutrients needed for plant growth (Evangelou et al. 2008).

Research to date confirms that wool waste has the potential to be used as a fertilizer, but a sustainable process is still needed to overcome all existing problems and to consider its application on an industrial scale.

The use of wool pellets in agriculture in Romania is still in its infancy so information on wool pellets produced in the country is relatively scarce. The researches in this paper seek to provide additional information on the physico–chemical properties of some wool pellets manufactured in Romania in order to better use of these organic fertilizers in Romanian agriculture.

2. MATERIALS AND METHODS

The wool pellets used for the measurements came from a producer in Ucea de Jos, Sibiu and were made with a pelleting press from raw, ground wool (Figure 1). The pellets were made in two versions with a diameter of 6 mm (P6) and 9 mm (P9). For comparison, imported pellets with a diameter of 4 mm (PT4) were used. For the P6 pellets, a raw wool, with many impurities, as obtained from sheep shearing, cut to 6mm length, was used. For the P9 pellets, clean wool with few impurities was used, previously cut to a length of 6 mm. We have no information about the raw material used for PT4 pellets. Some of the main quality indicators of wool pellets are presented in Table 1. The three types of pellets used for experiments are presented in Figure 2.

Table 1. Wool pellets quality indicators(analysis bulletin Raiffeisen Laborservice)

No.	Quality Indicators	U. M.	Determined values
1	Dry matter	%	89.30
2	pH measured at 20,6 0C	pH units	9.56
3	Density	g/l	0.33
4	Nitrogen	% D.M	12.14
5	P205	% D.M.	0.18
6	K20	% D.M	5.08
7	Sulphur	% D.M	2.11
8	CaO	% D.M	0.46
9	MgO	% D.M	0.19
10	Organic matter	g/kg D.M.	847.4
11	Humus–C	g/kg D.M.	460.4
12	Copper	mg/kg D.M	8.1
13	Iron	mg/kg D.M	2296
14	C:N ratio		3.8 :1

Figure 1 – Wool and press used for pellets: a) raw wool, b) grounded wool, c) pelleting press

Figure 2 – Wool pellets used in experiments: PT4–imported pellets with 4mm diameter; P6–raw wool pellets with 6 mm diameter; P9– clean wool pellets with 9 mm diameter

The experiments aimed to determine some characteristics of wool pellets, like water absorption capacity and bulk density.

To determine the bulk density of the wool pellets we used a calibrated vessel of volume V = 0.15 dm3 with mass m_{vas} = 79.37 g. For measurements we poured the granules into the vessel from a height of 5 cm, than the vessel was buffered 50 times by a wooden table and weighed again, to obtain the mass m_1. Five measurements were made for each pellet type. The measurements were repeated by 5 times to determine the average value of the m_1. Compact bulk density was calculated using the formula (1):

$$\rho = (m_1 - m) / V \quad (1)$$

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where: m_{vas} – mass of the vessel; V – volume of the vessel; m_1 – mass of the vessel with pellets

In order to determine the water absorption capacity of the pellets samples of 5 g were weighed (Figure 3) over which 10 g distilled water was added, after 10 minutes the excess water was removed and the saturated sample was weighed again. The water absorption relative to mass was calculated with the formula (2):

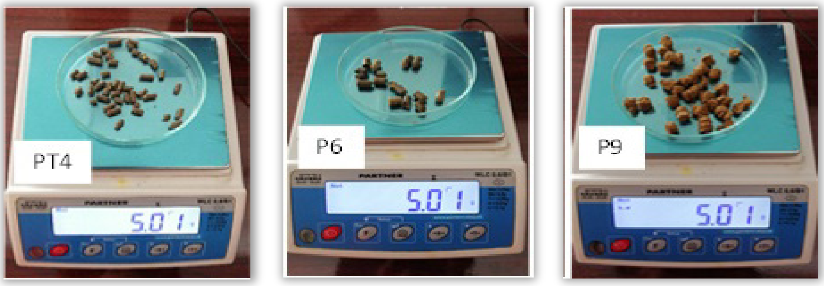

Figure 3 – Determination of dry mass of pellets

$$a_m=(m_{sa}-m_{us})*100/m_{us} \qquad (2)$$

where: m_{us} –dry mass of pellets, g; m_{sa} – saturated mass of pellets, g; a_m – water absorbtion relative to mass, %

3. RESULTS

In table 2 are presented the results obtained for bulk density of the wool pellets. It can be seen that PT4 and P6 pellets have similar bulk densities, unlike P9 pellets which have a lower bulk density – which is justified by the appearance of these pellets – much more aerated, probably due to the fact that they were made from wool with few impurities, such as soil, fat, vegetable residues.

Table 2. Bulk density of different wool pellets

	PT 4		P6		P9	
	m_1, g	ρ, kg/m³	m_1, g	ρ, kg/m³	m_1, g	ρ, kg/m³
V_{vas}=0,15dm³ m_{vas} =79,37 g	160,20	548,13	171,74	605,00	106,70	179,47
	160,53		170,36		105,85	
	163,67		168,02		106,59	
	161,98		171,23		107,25	
	161,57		169,24		105,07	


Figure 4 – Wool pellets samples at the time of adding the distilled water

Figure 5 – Wool pellets samples 10 minutes after adding distilled water

Table 3. Values of water absorbtion capacity for wool pellets

Sample	Water added g	Dry pellets m_{us}, g	Saturated pellets m_{sa}, g	Water absorbed a_m, %
PT4	10,17	5,01	13,78	175,05
P6	10,00	5,01	14,98	199,00
P9	10,38	5,01	15,38	206,99

By analyzing the data obtained from calculating the water absorbed relative to the mass for the three types of wool pellets and shown in Table 3, we note sample P9 of wool pellets absorb a higher amount of water due to their more aerate structure. The lowest water absorption capacity is observed in imported PT4–pellets, possibly due to some additives used in their production (the exact composition of these pellets is not known). Samples P6 and P9 made only of wool by pressing, show a much closer water absorption capacity, with a difference of only 7%, compared to a difference of 24–30% between these samples and PT4

4. CONCLUSIONS

The use of wool pellets from wool waste, as fertilizer is still a new field of application, for Romania.

A good knowledge of the characteristics of wool pellets allows a better management of them, both in terms of packaging, storage and transport, as well as in terms of the possibilities of land application.

From the results obtained, it can be observed that P9 pellets, which have a more aerated structure, have the lowest bulk density but the highest water absorption capacity. From these results it can be stated that in case of soil incorporation, wool pellets P9 will provide better aeration and a lighter soil structure, which it is beneficial for plants roots growing. Also the higher capacity of water absorption will lead to a faster disintegration of the pellets into soil.

Wool pellets P6 and PT4 which have a denser structure, have similar characteristics in terms of bulk density but a difference of 24% regarding water absorption capacity.

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References

[1] Adi Maria and Păcurar I., (2015). Study on the use sheep wool, in soil and fertilozation as the mixture into cubes nutrients. Proenvironment 8:290–292.
[2] Cai Z, Al Faruque MA, Kiziltas A, Mielewski D, Naebe M.(2021), Sustainable Lightweight Insulation Materials from Textile–Based Waste for the Automobile Industry, Materials, 14(5):1241
[3] El–Geundi MS, ((1997), Adsorbents for Industrial Pollution Control, Adsorption Science & Technology,15(10):777–787.
[4] Evangelou M.W.H., Ebel M., Koerner A., Schaeffer A., (2008), Hydrolysed wool: A novel chelating agent for metal chelant–assisted phytoextraction from soil, Chemosphere, 72, 525–531.
[5] Kumawat, T. K., Sharma, A., Sharma, V., & Chandra, S. (2018). Keratin waste: the biodegradable polymers. In Keratin. Ed.IntechOpen.
[6] Marchelli F, Rovero G, Curti M, Arato E, Bosio B, Moliner C. (2021), An Integrated Approach to Convert Lignocellulosic and Wool Residues into Balanced Fertilisers. Energies, 14(2):497
[7] Merli F, Belloni E, Buratti C. (2021), Eco–Sustainable Wood Waste Panels for Building Applications: Influence of Different Species and Assembling Techniques on Thermal, Acoustic, and Environmental Performance. Buildings. 11(8):361.
[8] Ordiales, E., Gutiérrez, J. I., Zajara, L., Gil, J., & Lanzke, M. (2016). Assessment of utilization of sheep wool pellets as organic fertilizer and soil amendment in processing tomato and broccoli. Mod. Agric. Sci. Technol, 2, 20–35.
[9] Remadevi R., Md Abdullah Al Faruque, Jizhen Zhang, Maryam Naebe,(2020), Electrically conductive honeycomb structured graphene composites from natural protein fibre waste, Materials Letters, 264:127311,
[10] Vončina, A., and R. Mihelič. (2013). Sheep wool and leather waste as fertilizers in organic production of asparagus (Asparagus officinalis L.). Acta Agriculturae Slovenica 101 (2):191–200
[11] *** Regulament al Parlamentului European și al Consiliului de stabilire a normelor privind punerea la dispoziție pe piață a produselor fertilizante cu marcaj CE și de modificare a Regulamentelor (CE) nr. 1069/2009 și (CE) nr. 1107/2009, Anexa 1, 2016

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