agriculture

MDPI

Article

Farmers' Attitudes toward On-Farm Adoption of Soil Organic Matter in Piedmont Region, Italy

Niccolò Pampuro, Federica Caffaro and Eugenio Cavallo *

Institute for Agricultural and Earth Moving Machines (IMAMOTER), Italian National Research Council (CNR), Strada delle Cacce, 73-10135 Torino (TO), Italy; n.pampuro@ima.to.cnr.it (N.P.); f.caffaro@ima.to.cnr.it (F.C.)
* Correspondence: e.cavallo@imamoter.cnr.it; Tel.: +39-0113977724

Received: 4 December 2019; Accepted: 7 January 2020; Published: 9 January 2020

check for updates

Abstract: This study aimed at exploring the frequency of use and perceived benefits of application of organic matter to the soil in a group of Italian farmers, investigating also the preferred sources of information, to identify potential interventions to promote the improvement of the soil organic matter. The study has been carried out administering a 21-item paper-and-pencil questionnaire to 44 farmers. The results of the study highlighted that the main perceived benefit linked to soil organic matter application is related to its capacity of increasing productivity, while the aspects related to work pace, production costs, and implications with the climate change appeared to be less relevant. According to the results of the study, web targeted information campaigns for the smaller farms operators and training activities for the bigger farms operators are the most effective solutions to make farmers aware of the importance of increasing soil organic matter content.

Keywords: organic wastes; recycling; soil management practices; agricultural operators; questionnaire

1. Introduction

Soil organic matter (SOM) plays a number of key roles in terrestrial ecosystems and agroecosystems, as related to the three components—chemical, physical, and biological—of soil quality and fertility. At a chemical point of view, SOM largely determines, together with clay minerals, the cation exchange (and anion retention) capacity of soil, pH buffering capacity, and the retention of inorganic or organic pollutants or toxic elements [1]. From the physical point of view, SOM is crucial in determining soil structure and thereby ultimately controlling soil erosion, water infiltration and holding capacity, habitat provision for plant roots, and soil organisms [2]. Furthermore, considering biological aspects, SOM is a primary source of energy for soil microorganisms and thus the whole soil food web, as well as a source of major nutrients, most notably nitrogen, phosphorus, and sulfur for plants and the soil biota [3]. At a global point of view, soils are a major reservoir of carbon (C) in terrestrial ecosystems, being the carbon stored in SOM containing more than three times as much C as either the atmosphere or the terrestrial vegetation. Soil organic matter can thus play a major role in mitigating climate change but, on the other hand, the decline of its content as a consequence of changes in land use or agricultural practices can substantially contribute to the emissions of C-CO_2 into the atmosphere.

Despite the relevant benefits of SOM, there is a clear evidence in decline of this element in many soils as a consequence of the unprecedented expansion and intensification of agriculture in 20th century [4]. This decline in SOM content is a threat to the sustainability of agricultural production systems because, as previously reported, SOM is a major component of soil fertility and quality. The Communication "Towards a Thematic Strategy for Soil Protection" [5], adopted by the European Parliament in April 2002, has identified eight main threats to soils, and considered declining SOM as one of the most serious processes of soil degradation, especially in Mediterranean countries [6]. In particular, as reported by Jones et al. [7], the Mediterranean Regions of Europe exhibits distinctively smaller values of organic carbon (OC) than those of other regions, with substantial areas showing low (≤2%), or very low (≤1%), OC.

Lal [4] reviewed and summarized the various strategies that can be used to preserve or increase the content of SOM in soils. In general, these consist of increasing the inputs of C or decreasing the losses, in both cases with several conventional and more novel options. Two types of inputs can be distinguished: the plant residues derived from the biomass grown on-site [4], and various types of biosolids that are most often exogenous materials, including livestock wastes, such as compost and digestate [8]. In this context, Delgado [9] affirmed that recycling of organic wastes on farms contributes to slow down the process of SOM decline.

SOM losses are influenced by farmers' soil management practices, which often rely heavily on the application of mineral fertilizers and intensive soil tillage [10]. As an example, the use of machinery for ploughing at different soil moisture conditions may affect soil aggregate stability with potential effect on soil erosion and related SOM losses [11]. Moreover, irrigation is widely used in drought-prone agricultural areas, to allow the adoption of intensified cropping systems, however this practice can induce an overall decrease in SOM [12].

Conceptual Framework and Aim of the Study

Previous studies pointed out the relevance of addressing farmers' perceptions about the use of organic matter to identify critical attitudes to be addressed with targeted interventions to encourage the adoption of practices which can increase the input of organic C [13].

When considering the adoption of new practices, a key process is represented by the transmission of information by two different channels, one impersonal (i.e., with no face-to-face exchange, such as the internet or the television) and one personal (i.e., with a direct face-to-face exchange), with the last subdivided into: formal contacts with institutionalized sources, as consultants or training activities, and informal contacts with peers and relatives [14]. Investigating the use of the different information sources by the farmers allows to identify potential areas for information campaigns and training activities to increase the adoption behavior of the targeted practice [15]. The adoption of innovations in agriculture is also influenced by the farm size: in their study, Cavallo et al. [16] affirmed that a more positive attitude toward agricultural innovations is related to larger farms or contractors. Despite the relevance of these factors in leading farmers' decisions regarding innovation and adoption of new practices, to the best of our knowledge, no previous studies investigated the role played by either the information sources or by farm size in affecting farmers' perceptions about the use of soil organic matter. Based on these considerations, this study aimed at exploring the frequency of use and perceived benefits of the use of organic matter among a group of Italian agricultural operators. The role of farm size and preferred sources of information about this subject have been also investigated to identify potential areas of interventions to promote the use of organic matter on farm to improve its content into the soil.

2. Materials and Methods

2.1. Participants and Context of the Study

Forty-four agricultural operators were involved in the study. They were all males. The main sociodemographic characteristics of the participants are reported in Table 1.

Table 1. Descriptive statistics of the sociodemographic characteristics of the participants.

Variable	Level	*n*	%	M	SD
Education	Elementary school	2	4.7		
	Middle school	14	32.6		
	High school	23	51.2		
	University degree	5	11.6		
On-farm occupation	Farmer	24	55.8		
	Farmworker	4	9.3		
	Other [a]	16	34.9		
Farm size	Up to 2 ha	4	9.8		
	2–9 ha	13	26.8		
	10–29 ha	7	17.1		
	30–49 ha	12	26.8		
	50 ha and over	8	19.5		
Farm operation	Cereals	11	25.0		
	Vineyard	17	38.6		
	Livestock	10	22.7		
	Forestry	6	13.7		
Age				40.8	19.1
Farming experience				18.6	16.8

[a] Includes the so-called 'part-time' farmers, those who do not have an official role in the agricultural industry but, in addition to their main occupation, spend time working in agriculture and using agricultural machinery [17].

The participants were recruited among the visitors of the 37th National Exhibition of Agricultural Mechanization in Savigliano, the largest agricultural machinery exhibition in the Piedmont Region.

The Piedmont Region is in NorthWest Italy. It represents about 4% and 8% of the total national agricultural holdings and Utilized Agricultural Area (UAA), respectively. In Piedmont, there are approximately 1 million hectares of UAA and 67,000 agricultural holdings with an average surface of 15 ha, very similar to those of the neighbouring regions of the Po valley (Lombardia 18 ha, Emilia Romagna 14.5 ha), while larger when compared to the national average (7.9 ha). The Piedmont covers 35% of the Po River catchment; 41% of the UAA is on the plane, mainly with maize-based systems, while 31% is on the hills, mainly with vineyards and winter cereals [18]. The Piedmont agricultural workforce represents about 4% of the national workforce in this sector [19]. Most of the farm owners are in the age range 35–64 (63%) and have a level of education equal to that of middle school (about 37%), whereas 25% have a high school diploma and fewer than 5% have a university degree [19].

In this geographical area, according to Fabietti et al. [20], agricultural soils are generally fertile, although often poor in organic matter (<2%). For this reason, the Piedmont Region represents a relevant context in which to investigate perceptions and attitudes toward the use of organic matter on farm.

2.2. Instruments

Participants were administered a 21-item paper-and-pencil questionnaire that was pilot-tested before use. In the first section, the participants were asked to indicate whether they actually used or intended to use the organic matter to improve its content in the soil of their farms on a 4-point rating scale (0: I do not use it and do not intend to adopt it; 1: I do not use it, but I may adopt it in the future; 2: I do not use it, but I am planning to adopt it; 3: I have already adopted it in my farm—adding also number of years). In the second section of the questionnaire, participants had to report on a 4-point scale (1: I do not at all agree; 4: I completely agree) their agreement with the following 6 statements on organic matter application: it slows down work pace (reverse), increases productivity, increases production costs (reverse), it is easy to use, it helps reducing climate change, and it helps protecting natural resources. In the third section, the participants had to indicate on a 4-point scale (1:

never; 4: often) how often they were exposed to the following different sources of information about the use of organic matter to increase its soil content: exhibitions, journals/advertisements/internet, training courses, discussions with peers/relatives, and discussions with consultants/trade organizations. A standard sociodemographic form that assessed participants' work-related characteristics (profession, years of experience in the agricultural sector and farm size) ended the questionnaire.

2.3. Procedure

Trained research assistants provided the questionnaire to exhibition attendees. The assistants explained the aims of the study and informed the participants that the questionnaire was anonymous. The questionnaire was in Italian, and its completion took approximately 5–6 min. No incentive was offered to participate in the survey.

2.4. Data Analysis

Descriptive statistics were computed for the variables of interest. Following the categorization used by the Italian National Agricultural Census [21], and to make group sizes more comparable, farm sizes were re-grouped into small and medium farms (up to 29 ha) vs. big farms (over 30 ha) for subsequent analysis. A series of non parametric Mann–Whitney U tests were then perfomed to investigate any significant difference in perceived benefits and preferred information sources between smaller/medium vs. bigger farms.

3. Results and Discussions

Forty-one participants have already used organic matter for application on their farms (for an average of 17.8 years (SD = 7.1)), while other three participants intended to adopt it in the near future or were planning to adopt it. The main perceived benefit of using organic matter was related to its capacity of increasing productivity, while the aspects related to work pace, production costs and climate change appeared to be less relevant in participants' evaluation of the practice (Figure 1). The Mann–Whitney test pointed out a significant difference between smaller/medium farms and bigger farms with regard to the capability of organic matter to increase productivity (U = 134,000, p = 0.027), with higher perceived benefit in bigger farms. However, as highlighted by many studies [22,23], the application of organic matter as a partial substitute for the mineral fertilizers, could lead to a reduction in production costs, increasing farm profitability. Moreover, soil organic matter is considered to have the potential to mitigate climate change by C sequestration globally and thus compensate at least a part of the fossil fuel emissions and at the same time restore soil fertility [24].

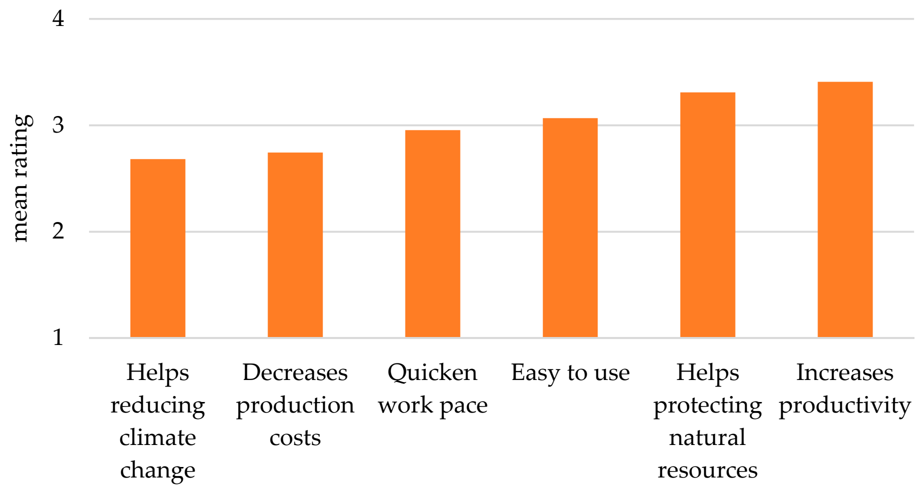

Figure 1. Mean rate of agreement with different statements regarding the use of soil organic matter.

With regard to the use of different communication channels, the participants looked more often for information on the internet, and by discussing with informal contacts, such as other operators, neighbors and/or friends, while seminars and training courses were not used as communication channels on organic matter application to improve its content into the soil (Figure 2).

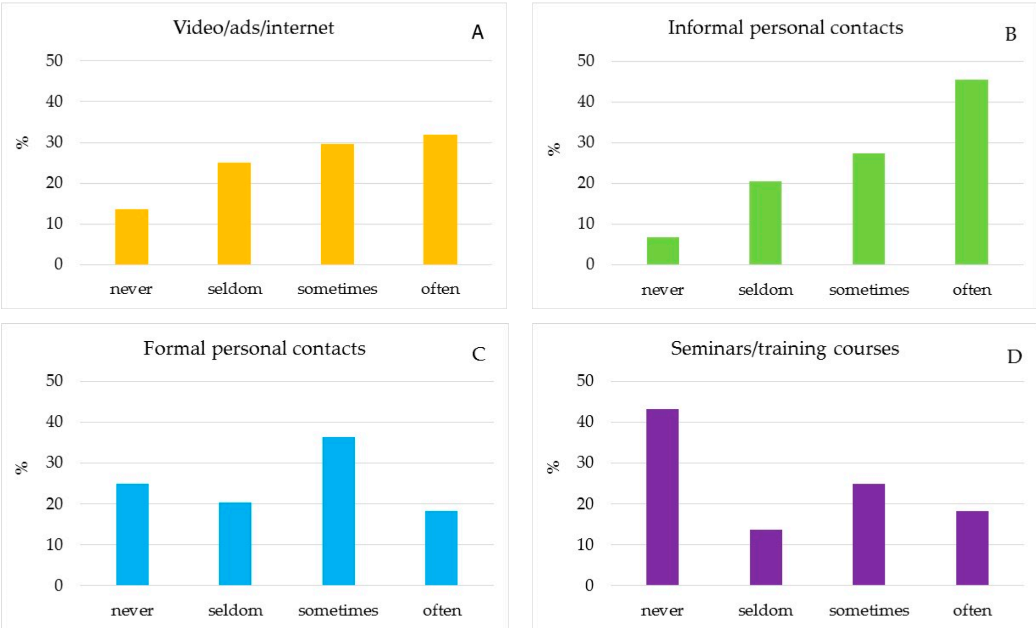

Figure 2. Percentages of responses on the frequency of use of the different information sources: (**A**) videos/ads/internet; (**B**) informal personal contacts (neighbors, other farmers); (**C**) formal personal contacts (farmers' association, consultants); (**D**) seminars/training courses.

When considering possible differences among farms with different sizes (Figure 3), it appears that informal contacts and formal channels of communication [14] such as discussions with consultants and farmers' organizations were mainly used by bigger farms, whereas small and medium farms more often refer to advertisements and web sources to gather information on the use of organic matter. The Mann–Whitney test showed a trend toward significance (U = 142,000, $p = 0.065$) for a more frequent use of training and seminars in bigger farms compared to smaller/medium farms.

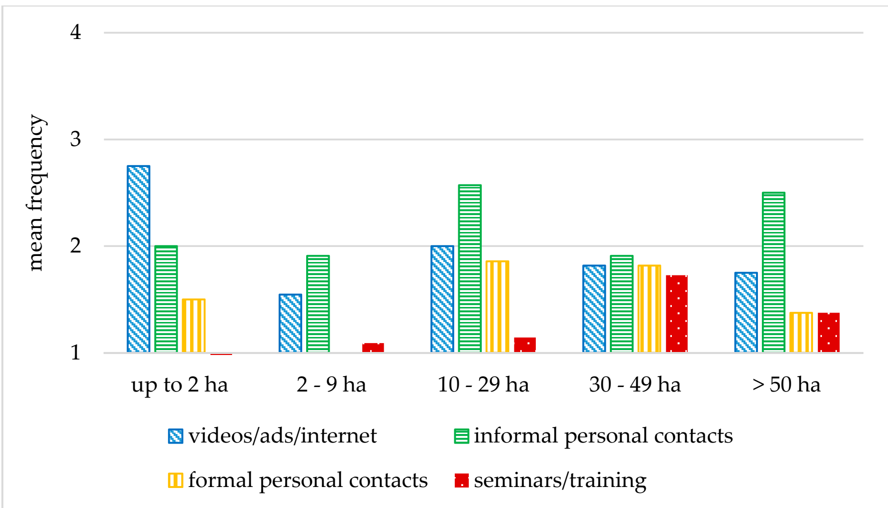

Figure 3. Mean ratings of frequency of use of the different information sources per different farm sizes.

4. Conclusions

The present study aimed at investigating perceptions and attitudes toward the use of organic matter on farm in a group of agricultural operators in Piedmont. A group of farmers and farmworkers were administered a questionnaire assessing the actual use and perceived usefulness of the adoption of organic matter application on soils' farm, together with the preferred sources of information, to identify potential areas of interventions to promote its use.

The obtained results highlighted a low perception of the benefits associated with the use of soil organic matter, which plays a key role in determining the quality, productivity and eco-logical functioning of soils affecting, directly or indirectly, chemical, biological, and physical properties of belowground components.

Regarding the different information channels, informal discussions with peers appeared to be the most frequently used source of information among our participants. Referring to Rogers' [14] terminology, our participants learn from their "homophilic neighbors", which means, individuals with whom farmers have close social ties and share common professional or/and personal characteristics. Information on organic matter may then be disseminated in a way that can make farmers aware of the benefits associated with the use of organic matter and promote positive attitudes in the potential users, which may be later spread during informal conversations.

Based on the obtained results, farmers from smaller and bigger farms turn to different types of sources to obtain information about the use of organic matter, with small farms counting mostly on impersonal sources of information (internet and mass media) and big farms on informal contacts. Web information campaigns with simple contents and layout, showing how to use organic matter in smaller farms to increase economic and environmental benefits may be developed to make smaller farms operators aware of the importance of increasing soil organic matter content.

The present results should be interpreted with caution due to the fact that the study has been performed on a small group of participants recruited among the visitors of an agricultural exhibition in Piedmont region. More generalizable results will be available in future studies interviewing larger samples of participants in other regions of the country.

Author Contributions: N.P., F.C., and E.C. conceived and designed the study; N.P. and F.C. analyzed the data; N.P., F.C., and E.C. wrote the paper. All authors have contributed substantially to the work reported. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Molina-Herrera, S.; Romanya, J. Synergistic and antagonistic interactions among organic amendments of contrasted stability, nutrient availability and soil organic matter in the regulation of C mineralization. *Eur. J. Soil Biol.* **2015**, *70*, 118–125. [CrossRef]
2. Minasny, B.; McBratney, A.B.; Salvador-Blanes, S. Quantitative models for pedogenesis—A review. *Geoderma* **2008**, *144*, 140–157. [CrossRef]
3. Shi, P.; Schulin, R. Erosion-induced losses of carbon, nitrogen phosphorous and heavy metals from agricultural soils of contrasting organic matter management. *Sci. Total Environ.* **2018**, *618*, 210–218. [CrossRef] [PubMed]
4. Lal, R. Challenges and opportunities in soil organic matter research. *Eur. J. Soil Sci.* **2009**, *60*, 158–169. [CrossRef]
5. Commission of the European Communities (CEC). *Towards a Thematic Strategy for Soil Protection; 16/04/2002 COM.; Communication from the Commission to the Council, the European Parliament, the Economic and Social Committee and the Committee of the Regions*; CEC: Bruxelles, Belgium, 2002; p. 35.
6. Montanarella, L.; Pennock, D.J.; McKenzie, N.; Badraoui, M.; Chude, V.; Baptista, I.; Mamo, T.; Yemefack, M.; Aulakh, M.S.; Yagi, K.; et al. World's soils are under threat. *Soil J.* **2016**, *2*, 79–82. [CrossRef]

7. Jones, R.J.A.; Hiederer, R.; Rusco, E.; Loveland, P.J.; Montanarella, L. The map of organic carbon in topsoils in Europe, Version 1.2, September 2003: Explanation of Special Publication Ispra 2004 No. 72 (S.P.I.04.72). In *European Soil Bureau Research No.17, EUR 21209 EN, 26pp. and 1 Map in ISO B1 Format*; Office for Official Pubblications of the European Communities: Luxembourg, 2004.
8. Pampuro, N.; Bisaglia, C.; Romano, E.; Brambilla, M.; Foppa Pedretti, E.; Cavallo, E. Phytotoxicity and chemical characterization of compost derived from pig slurry solid fraction for organic pellet production. *Agriculture* **2017**, *7*, 94. [CrossRef]
9. Delgado, J. Crop residue is a key for sustaining maximum food production and for conservation of our biosphere. *J. Soil Water Conserv.* **2010**, *65*, 111–116. [CrossRef]
10. Viaene, J.; Van Lancker, J.; Vandecasteele, B.; Willekens, K.; Bijttebier, J.; Ruysschaert, G.; De Neve, S.; Reubens, B. Opportunities and barriers to on-farm composting and compost application: A case study from northwestern Europe. *Waste Manag.* **2016**, *48*, 181–192. [CrossRef] [PubMed]
11. Dell'Abate, M.T.; Bazzoffi, P.; Ciancaglini, A.; Francaviglia, R.; Galeffi, C.; Napoli, R.; Neri, U.; Pennelli, B. Effectiveness of the GAEC cross-compliance standard ploughing in good soil moisture conditions in soil structure protection. *Ital. J. Agron.* **2011**, *6*, e10. [CrossRef]
12. Costantini, E.A.C.; Lorenzetti, R. Soil degradation processes in the Italian agricultural and forest ecosystems. *Ital. J. Agron.* **2013**, *8*, 233–243. [CrossRef]
13. Pampuro, N.; Caffaro, F.; Cavallo, E. Reuse of animal manure: A case study on stakeholders' perceptions about pelletizzed compost in Northwestern Italy. *Sustainability* **2018**, *10*, 2028. [CrossRef]
14. Rogers, E.M. *Diffusion of Innovations*, 5th ed.; Simon and Schuster: New York, NY, USA, 2003.
15. Unay Gailhard, İ.; Bavorová, M.; Pirscher, F. Adoption of agri-environmental measures by organic farmers: The role of interpersonal communication. *J. Agric. Educ. Ext.* **2015**, *21*, 127–148. [CrossRef]
16. Cavallo, E.; Ferrari, E.; Bollani, L.; Coccia, M. Attitudes and behaviour of adopters of technological innovations in agricultural tractors: A case study in Italian agricultural system. *Agric. Syst.* **2014**, *130*, 44–54. [CrossRef]
17. Caffaro, F.; Roccato, M.; Micheletti Cremasco, M.; Cavallo, E. Part-Time Farmers and Accidents with Agricultural Machinery: A Moderated Mediated Model on the Role Played by Frequency of Use and Unsafe Beliefs. *J. Occup. Health* **2018**, *60*, 80–84. [CrossRef] [PubMed]
18. Istituto Nazionale di Economia Agraria (INEA). *Italian Agriculture in Figures 2013*; INEA: Rome, Italy, 2014. Available online: http://dspace.crea.gov.it/bitstream/inea/843/1/Italian_agriculture_figures_2013.pdf (accessed on 22 November 2019).
19. ISTAT. *6° Censimento Generale dell'Agricoltura 2010: Caratteristiche strutturali delle aziende agricole [6th National Agricultural Census 2010: Farms Characteristics]*; ISTAT: Rome, Italy, 2010; Available online: https://www.istat.it/it/files/2011/03/1425-12_Vol_VI_Cens_Agricoltura_INT_CD_1_Trimboxes_ipp.pdf (accessed on 27 November 2019).
20. Fabietti, G.; Biasioli, M.; Barberis, R.; Ajmone-Marsan, F. Soil contamination by organic and inorganic pollutants at the regional scale: The case of Piedmont, Italy. *J. Soil Sediment* **2010**, *10*, 290–300. [CrossRef]
21. ISTAT. *6° Censimento Generale dell'Agricoltura 2010: Risultati definitivi [6th National Agricultural Census 2010: Final Results]*; ISTAT: Rome, Italy, 2012; Available online: https://www.istat.it/it/files/2012/07/sintesi.pdf (accessed on 2 December 2019).
22. Gil, M.V.; Carballo, M.T.; Calvo, L.F. Fertilization of maize with compost from cattle manure supplemented with additional mineral nutrients. *Waste Manag.* **2008**, *28*, 1432–1440. [CrossRef] [PubMed]
23. Pampuro, N.; Bertora, C.; Sacco, D.; Dinuccio, E.; Grignani, C.; Balsari, P.; Cavallo, E.; Bernal, M.P. Fertilizer value and greenhouse gas emissions from solid fraction pig slurry compost pellets. *J. Agric. Sci.* **2017**, *155*, 1646–1658. [CrossRef]
24. Van Wesemael, B.; Chartin, C.; Wiesmeier, M.; von Lutzow, M.; Hobley, E.; Carnol, M.; Kruger, I.; Campion, M.; Roisin, C.; Hennart, S.; et al. An indicator for organic matter dynamics in temperate agricultural soils. *Agric. Ecosyst. Environ.* **2019**, *274*, 62–75. [CrossRef]