



Article Farmers' Perceptions and Willingness of Compost Production and Use to Contribute to Environmental Sustainability

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Abstract: Composting is an ecological method of recycling organic waste. It presents an effective solution to reduce the large volume of agricultural waste and provides an organic fertilizer and soil amendment. However, its implementation remains limited, especially in Morocco. The vast majority of farmers are unaware of the effectiveness of compost, and it is often considered as an inefficient product compared with chemical fertilizers. In order to develop a local marketing strategy for compost, this study aims to identify the perceptions and willingness of farmers to produce and use compost in agriculture, and to assess the factors shaping these perceptions and willingness, including socio-economic, agricultural and individual factors. The case of Morocco is investigated, where the vast majority of farmers practice inappropriate disposal of agricultural waste and excessive use of agro-chemicals. Data are collected using a standard questionnaire and face-to-face interviews with 350 farmers during their visit to the international agricultural exhibition in Morocco. Descriptive statistics and analysis of variance (ANOVA) are used for data analysis. The results showed a high level (80%) of acceptance by farmers of the production and use of compost. Farmers are also very willing to produce and use compost in agriculture. All the socio-economic, individual and agricultural factors, except gender, length of experience and cultivated area, had a highly significant influence on farmers' perception and willingness to produce compost (p < 0.005). The positive perceptions of farmers and the high level of willingness to produce compost imply that the composting of organic waste should be encouraged by our local authorities. The production of compost will thus contribute to environmental sustainability and to the promotion of the ecological management of agricultural waste meeting the requirements of a circular economy.

Keywords: agricultural waste; compost; farmers' willingness; farmers' perceptions; socio-economic factors; individual factors; agricultural factors; Morocco; environmental sustainability; circular economy



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1. Introduction

In the past decades, an ever-increasing production of waste has been spread all over the world. Urbanization, human behavior, consumption rate, population explosion as well as socio-economic and industrial activities development are all the factors mostly responsible for this dramatic increase. As wastes are always considered either unusable or disposable, its disposal causes serious environmental problems and harmful effects on human health. Indeed, these wastes include all residues and effluents generated by various human activities, generally of plant or animal origin, and may even be in liquid, solid or sludge form [1–3], (pp. 123–145 [3]), [4].

In Morocco, the annual production of solid waste is about 6.9 million tons [5,6]. Urban wastewater discharges are estimated at 500 million m³ [7]. More than 1.5 million tons of solid waste and about 931 million m³ of wastewater are produced annually by the industrial sector [5–7]. Despite the considerable efforts made by the Moroccan government to limit the environmental hazards relating to the problem of this waste, its management has so far remained limited. Only 10% of the household waste generated and 23% of the industrial waste produced is recycled, of which 73% is evacuated to technical landfills and 4% is incinerated [8]. Moreover, only 37% of the waste generated is disposed of in controlled landfills, while the majority is disposed of in uncontrolled landfills [5]. These inadequate and poor waste management practices result in a multiplicity of adverse impacts on the environment. According to the report of the World Bank Group [9], the cost of environmental degradation at the national level is estimated at 3.52% of the GDP, i.e., MAD 32.5 billion, of which poor waste management practices represent a relatively significant cost of degradation estimated at MAD 3.7 billion representing 0.4% of GDP. Therefore, good waste management is necessary to reduce or eliminate all environmental risks.

In order to deal with this challenging area, various treatment techniques have been developed, including physical, physicochemical and biological processes [10–14]. Some of these processes appear to be effective, and their application depends mainly on socioeconomic constraints. Hence, much attention has been paid to the conversion of organic waste into valuable products useful for sustainable agricultural practices [1,2,14,15].

Currently, various research studies have shown that composting is one of the most effective methods for the recycling and recovery of organic waste [2,4,16–19]. It is a biodegradation process of the organic matter, allowing the obtaining of a stable product, rich in humic substances and in fertilizing elements, serving as a soil organic amend-ment [2,20]. This technique presents a promising alternative that responds favorably to the imperatives of a circular economy. It reduces the environmental impact of waste by reducing its volume, provides organic matter to agricultural soils and nutrients to stimulate plant growth and protects against phytophatogenic diseases [17,20–25].

Despite its advantages, the implementation of composting remains limited, the vast majority of farmers are unaware of the effectiveness of compost and it is often considered an ineffective product compared to chemical fertilizers. Therefore, it is necessary to identify farmers' perceptions and willingness to produce and use compost to determine a good strategy of marketing compost.

Most studies assessing farmers' willingness to produce and use compost have been conducted internationally, namely in Ethiopia, Cameroon, Ghana, China and Palestine. These studies report that farmers' perceptions and willingness are conditioned by socio-economic, agricultural and individual factors [25–31].

Given the limited amount of Moroccan research examining farmers' willingness to produce or use compost, this study considers it necessary to identify farmers' perceptions and willingness to produce and use compost on a national level. It also examines the different socio-economic, agricultural and individual factors that shape farmers' perceptions and willingness: socio-economic factors such as gender, age, education level, type of agricultural production and duration of experience and agricultural factors such as type of plant and animal production, area of cultivated land, kind of fertilizers used, use of pesticides, farm's production of plant and/or animal waste and method waste management enterprise. Individual factors are factors related to the individual such as knowledge and experience associated with compost production and use. Farmer perception in this study refers to the farmer's opinion of the overall concept. However, farmer willingness assumes that the farmer is willing to produce the compost himself and use it in agriculture. The assumption is that support for the mere idea of compost production cannot be taken as approval or willingness to implement it.

2. Research Methodology

This case study investigates the perceptions and willingness of farmers to produce and use compost in agriculture and assesses the factors that shape these perceptions and willingness, including socioeconomic, agricultural and individual factors. To this end, the survey uses a mixed-methods research design that includes qualitative and quantitative methods. This approach provides a better understanding of the research problem, and thus a greater validity of the findings can be achieved. Indeed, the use of mixed methods allows multiple lines of evidence to be combined. It provides more detailed answers to research questions, while providing research participants with the opportunity to express their views and have face-to-face interactions with their interlocutors, allowing them to probe and stimulate conversation to uncover important context-specific information that may not have been captured by a quantitative approach alone [25,32–34].

2.1. Study Area

The area chosen for this study is the international agricultural exhibition in Morocco (SIAM). SIAM is one of the largest events in the agricultural sector worldwide due to its large surface area, its thematic poles and the growing number of visitors. It is an annual event which aims to bring together the farming family and give substance to cooperatives and associations by enabling them to exhibit and market their products. In addition, this agricultural event is a favorable occasion for the exchange of experiences between the different exhibitors as well as the conclusion of agreements with foreign associations [35].

According to Siam's review, this exhibition noted a number of visitors that amounts to 850,000 over a total area of 185,000 m², with 1365 exhibitors and the participation of 60 countries and 331 cooperatives and associations all interested in the innovations in agriculture and its development [35].

2.2. Census Data

2.2.1. Farmers' Questionnaire

The data were collected through using a standard questionnaire and a face-to-face interviews with farmers visiting the SIAM as described by Al-Madbouh et al. [25].

The farmers' questionnaire provided important information and data on what shapes farmers' perceptions and willingness to produce and use compost, focusing on socioeconomic, agricultural and individual factors. The questionnaire was supported by private interviews with farmers, which allowed us to gain insight into the factors that influence farmers' perceptions and their willingness to produce and use compost. The questionnaire, hence, collected information on dependent variable including farmers' perceptions and willingness to produce and use compost after appropriate training. The variable reflects whether a farmer accepts or does not accept the idea of compost production and if he is willing or unwilling to produce and use it after receiving relevant training.

The questionnaire also covered 21 independent variables related to the following three categories:

Socio-economic characteristics of farmers including gender, age, level of education, average household monthly income, number of household members, type of agricultural production of the farmer and length of experience;

The agricultural profile of farmers including type of agricultural business (plant or animal agriculture), area of cultivated lands, farm's production waste, method of farm's waste management, kind of fertilizers used and use of pesticides; The individual variables related to the farmer's perception and willingness to produce and use compost, including farmer's previous knowledge of compost, previous use of compost as a fertilizer, experience of compost production, previous training attained on compost production, reasons of not using compost and perceived economic benefits of compost production.

The questionnaire for farmers was developed in the French language and translated into the Moroccan dialect for farmers. Afterwards, it was then subjected to a pilot test with 10 randomly selected persons in order to readjust it in case of any anomaly.

2.2.2. Sampling and Interview Procedures

A statistically representative sample of 350 farmers was determined using a stratified random sampling technique taking into account the size of the international agricultural exhibition and the number of visitors who agreed to participate. Fieldwork visits took place throughout the period of the fair; the research team was divided in two: One remained stationary at the stand of the University Sidi Mohammed Ben Abdellah and received visitors to the stand, and the other mobilized to cover the four corners of the fair. A total of 350 farmers were interviewed, of which 301 (73.6%) were from upstream and 108 (26.4%) from the middle and downstream areas. Interviews were conducted in the Moroccan dialect—the mother tongue of the participants—and each interview lasted between 15 and 25 min.

2.3. Data Analysis

The questionnaire data were analyzed using statistical and econometric methods using Social Science Software (IBM SPSS statics) version 20. Descriptive statistics including frequency and percentage are used to describe the socio-economic characteristics and agricultural profile of the study population. Analyses of variance (ANOVA) are carried out to assess the characteristics that most influence farmers' perception and willingness to accept the idea of producing and using compost. Table 1 presents description of the independent variables related to farmers' perceptions and willingness of compost production and use.

Variable	Description	Definition	
X ₁	Gender	Male = 1 Female = 2	
X ₂	Age (year)	<30 years = 1 30–50 years = 2 >50 years = 3	
X ₃	Average household monthly income (MAD)	<mad 2000="1<br">MAD 2000-5000 = 2 MAD 5000-10,000 = 3 >MAD 10,000 = 4</mad>	
X ₄	Level of education	Illiterate = 1 Elementary = 2 Secondary = 3 Post-secondary/university = 4	
X ₅	Number of household members	1-4 4-8 >8	
X ₆	Type of agricultural production	Plant production = 1 Animal production = 2 Mixed plant and animal production = 3	

Table 1. Description of independent variables studied.

Table 1. Cont.

Variable	Description	Definition	
X ₇	Duration of experience (year)	10 years = 1 10–20 years = 2 >20 years = 3	
X ₈	Area of cultivated (ha)	<5 ha = 1 5–15 ha = 2 >15 ha = 3	
X9	Type of plant production	Cultivating vegetables, legumes and/or grains = Growing trees = 2	
X ₁₀	Type of animal production	Poultry farming = 1 Livestock raising = 2	
X ₁₁	Farm's production of plant and/or animal waste	Yes = 1 No = 2	
X ₁₂	If the farm produces waste, method waste management	Burn and/or dispose randomly = 1 Use as soil fertilizer = 2 Use as animal feed = 3	
X ₁₃	Kind of fertilizers used	Chemical fertilizers only = 1 Compost only = 2 Chemical fertilizers + compost = 3	
X ₁₄	Use of pesticides	Yes = 1 No = 2	
X ₁₅	Knowledge of compost use or production	Yes = 1 No = 2	
X ₁₆	Training attained on compost production	Yes = 1 No = 2	
X ₁₇	Previous use of compost as a fertilizer	Yes = 1 No = 2	
X ₁₈	Previous experience of compost production	Yes = 1 No = 2	
X ₁₉	Reasons of not using compost	I do not know about it = 1 I do not know how to use it or produce it = 2 Compost is more expensive than chemical fertilizer = 3 Inadequate area of agricultural lands = 4	
X ₂₀	Perceptions and Willingness to produce and use compost after receiving training	Yes = 1 No = 2	
X ₂₂	In case of experience, perceived economic benefits of compost production	Yes = 1 No = 2	

3. Results and Discussions

3.1. Respondents' Socio-Economic Characteristics

The study findings reveal that all farmers surveyed (n = 350) are 100% males. Of those, 10.3% of them are younger than 30 years old, 69.7% are between 30 and 50 years old and only 20% of the respondents are older than 50 years old (Table 2). This male dominance does not mean the absence of women in the Moroccan agricultural sector; it rather reveals our customs and traditions. Most of the women to which we turned refused to answer the questionnaire, justifying themselves by the fact that it is the male's responsibility to answer.

Variable	Definition	N (%)
Gender	Male = 1 Female = 2	350 (100) 0 (0)
Age (year)	<30 years = 1 30–50 years = 2 >50 year = 3	36 (10.3) 244 (69.7) 70 (20)
Level of education	Illiterate = 1 Elementary = 2 Secondary = 3 Post-secondary/university = 4	141 (40.3) 70 (20) 104 (29.7) 35 (10)
Type of agricultural production	Plant production = 1 Animal production = 2 Mixed plant and animal production = 3	105 (30) 158 (50) 87 (20)
Duration of experience (year)	10 years = 1 10–20 years = 2 >20 years = 3	35 (10) 245 (70) 70 (20)

Table 2. Frequencies and percent distribution of responses related to farmers' socio-economic characteristics (n = 350).

Unfortunately, all the respondents refused to provide information on their average household size and average monthly income, but they did share their level of education, type of activities and years of experience. The results show also that 40.3% of the farmers interviewed are illiterate, 20–30% have received some education between primary and secondary school and only 10% have a good level of education (university). For the type of production, the most dominant among the participants was animal production (50%) followed by 30% agricultural production and only 20% of the farmers surveyed combined them both (animal and agricultural).

3.2. Respondents' Agricultural Profile

This study shows that 90% of farmers practicing plant agriculture cultivate legumes, vegetables and cereals, and only 10% grow trees (Table 3). The vast majority of these farmers are of medium level, cultivating areas of between 5 and 15 ha, 20% are large farmers with areas larger than 15 ha and only 10% are small farmers cultivating fields of less than 5 ha. The study also shows that 90% of farmers practicing animal farming keep livestock and only 10% keep poultry.

Description	Definition	N (%)
Type of plant production ($n = 105$)	Cultivating vegetables, legumes and/or grains = 1	94.5 (90)
	Growing trees $= 2$	10.5 (10)
Type of animal production $(n - 150)$	Poultry farming = 1	15 (10)
Type of animal production $(n = 150)$	Livestock raising = 2	135 (90)
	<5 ha = 1	28.8 (15)
Area of cultivated ($n = 192$)	5–15 ha = 2	144 (75)
	>15 ha = 3	19.2 (10)
	Chemical fertilizers only = 1	172.8 (90)
Kind of fertilizers used $(n = 192)$	Compost only $= 2$	19.2 (10)
	Chemical fertilizers + compost = 3	0 (0)
Use of posticides $(n - 192)$	Yes = 1	172.8 (90)
Use of pesticides $(n = 192)$	No = 2	19.2 (10)

Table 3. Frequencies and percent distribution of responses related to farmers' agricultural profile.

Description	Definition	N (%)
Farm's production of plant and/or animal waste ($n = 350$)	Yes = 1 No = 2	315 (90) 35 (10)
If the farm produces waste, method waste management ($n = 315$)	Burn and/or dispose randomly = 1 Use as soil fertilizer = 3 Use as animal feed = 4	31.5 (10) 220.5 (70) 63 (20)

Table 3. Cont.

However, all farms run by the quasi-totality of interlocutors (90%) produce waste. It is noted that for the management of these wastes, the data represented that 70% of farmers use them as fertilizers or organic amendments for their agricultural soil, and 20% use them as animal feed, especially when it is wasted from agricultural production. Only 10% burn their waste, dispose of it randomly or in household waste containers.

Regarding the kinds of soil fertilizers used by the respondents, direct questions were asked and it turned out that 90% use chemical fertilizers and pesticides, and only 10% opt for organic farming and use organic amendments such as compost.

These results corroborate those found by Al-Madbouh et al. and Wang et al., which reveal that the recycling and reuse of agricultural products is a widely accepted idea by farmers because of their ecological value [25,30]. These authors showed that in both China and Palestine, the majority of farmers reuse their waste, thus promoting an ecological approach to agricultural waste management while protecting the environment. Al-Madbouh et al. [25] instead showed that the vast majority of these farmers do not have the courage to practice organic farming. His work has shown that the vast majority of farmers are nowadays using chemical fertilizers and pesticides excessively.

3.3. Farmers' Perceptions and Willingness of Production and Compost Use

Our study revealed a low level of knowledge of compost among the farmers surveyed. The majority of respondents (80%) were not familiar with compost and only 20% said they had heard of it or used it as a soil amendment rather than fertilizer (Table 4). Almost all of these farmers (90%) also confirmed that this is a new product on the market and that they had not received any training on the subject.

The study also showed that only 30% of farmers have already produced compost. These farmers were composting in an anarchic way; for them, it was a traditional way of recycling their waste only. For those who have never used compost, they expressed different reasons mainly related to the lack of knowledge. More than half of the farmers interviewed (73.5%) expressed that they did not know compost, 10% did not know how to use it or how to produce it, 10% found it expensive compared to chemical fertilizers and 10% explained that the surface area of their farmland was insufficient and did not allow them to treat their waste and produce compost.

After having presented compost and defined its advantages to all participants, a direct question was asked to know the perceptions and willingness of farmers to produce and use compost from agricultural waste. The results of the study showed a high level of acceptance for the idea of producing and using compost by the farmers interviewed. A total of 80% accepted the idea, while only 20% refused it. When farmers are asked about their willingness to produce and use compost in agriculture, the results are the same. We also find that 80% of farmers are willing to produce compost themselves and use it in agriculture.

Description	Definition	N (%)
Knowledge of compost use or production	Yes = 1	280 (80)
(<i>n</i> = 350)	No = 2	70 (20)
Training attained on compost production	Yes = 1	35 (10)
(n = 350)	No = 2	315 (90)
Previous use of compost as a fertilizer	Yes = 1	0 (0)
(n = 350)	No = 2	350 (100)
Providue experience of compact production	Yes = 1	105 (30)
rievious experience of compost production	No = 2	245 (70)
In case of experience, perceived economic benefits of compost production	Yes = 1	21 (20)
$(n = 105)^{1}$	No = 2	84 (80)
	I do not know about it = 1	56 (70)
Process of not using compact	I do not know how to use it or produce it = 2	8 (10)
(n = 80)	Compost is more expensive than chemical fertilizer = 3	8 (10)
	Inadequate area of agricultural lands = 4	8 (10)
Perceptions and willingness to produce and	Yes = 1	280 (80)
use compost after receiving training	No = 2	70 (20)

Table 4. Frequencies and percent distribution of farmers' responses to perceptions and willingness of compost production.

In the same line as our findings, Nigussie et al., Wang et al. and Al-Sari et al. reported high acceptance levels among farmers in Ethiopia, China and Palestine for the idea of producing and using compost [20,29,30]. Whereas another case study in Palestine instead showed a 20% difference between farmers' positive perceptions and their willingness to produce and use compost in agriculture, the study showed that support decreases when a reuse option becomes more concrete [25].

However, farmers' perceptions and willingness were influenced by a combination of socio-economic, agricultural and individual factors [20,25,30].

3.4. Factors Shaping Farmers' Perceptions and Willingness of Compost Production and Use

The results of the analyses of variance suggest that a combination of several socioeconomic, agricultural and individual factors have statistically significant associations (p value < 0.05) with farmers' perception and willingness to produce and use compost. Table 5 represents the results of the analyses of variance on the socio-economic, agricultural and individual variables that shape farmers' perceptions and willingness. The analysis of the results shows that for the socio-economic factors, all the variables studied significantly influence farmers' perceptions and willingness to produce and use compost, with the exception of gender, which varies in a non-significant way. In agreement with this result, Al-Madbouh et al. showed that gender does not significantly affect farmers' perception and willingness to produce and use compost [25]. The same study revealed that the average monthly household income and the farmers' area of residence are among the socio-economic factors that shape farmers' perception of compost production in a highly significant way [25]. Our results were also confirmed by another study conducted in Cameroon, which showed that age has a significant influence on the willingness of farmers to produce and use compost and that young farmers are the most motivated to use compost [26].

Factors	Variables	Perceptions and Willingness to Produce and Use Compost		
		M.S.	F	p Value
Socio-economic	Gender	0.008	0.003	0.968 ^{ns}
	Age	71.326	791.209	0.0002 **
	Level of education	71.778	8.548	0.0039 **
	Type of agricultural business	1338.6864	470.536	< 0.0001 ***
	Duration of experience	0.875	3.026	0.0828 ^{ns}
	Type of plant production	14	278.400	< 0.0001 ***
	Type of animal production	10	208.150	< 0.0001 ***
	area of cultivated	0.2890	3.026	0.0828 ^{ns}
Agricultural	Kind of fertilizers used	126	278.400	0.0004 **
	Use of pesticides	190.000	471.400	0.0007 **
	Farm's production of plant and/or animal waste	14	228.400	0.0029 *
	If the farm produces waste, method of waste management	105.875	765.600	0.0020 *
Individual	Knowledge of compost use or production	56	310.5	0.0030 *
	Training attained on compost production	0.875	9.943	0.002 **
	Previous use of compost as a fertilizer	30.625	121.304	0.0414 *
	Previous experience of compost production	7.875	56.945	< 0.0001 ***
	Reasons of not using compost	14	6.187	0.013 **
	In case of experience perceived economic benefits of compost	17.225	76.598	< 0.0001 ***

Table 5. Findings of the variance analyses on socioeconomic, agricultural and individual variables shaping farmers' perceptions and willingness.

^{ns}: p > a = 0.05: differences not significant; *: p < a = 0.05 differences just significant; **: p < a = 0.01: highly significant differences; **: p < a = 0.001: highly significant differences; F: Fisher's F value; M.S.: root mean square.

In addition, the results of the analysis of variance also reveal that the surface area of agricultural land varies in a non-significant way with the willingness to produce and use compost. However, knowledge of compost, its production and use techniques, its benefits and the experience of farmers in producing or using compost are important factors that significantly influence farmers' perception and willingness to produce and use compost. In view of these results, we find that individual factors are of great influence on the willingness to produce and use compost. The same finding has been proven by other authors who have shown that individual factors, mainly knowledge of compost and its benefits, significantly influence farmers' perceptions and willingness to produce [20,25,29,30].

4. Conclusions

The study findings reveal that young men with an average age between 30 and 50 years dominate the practice of all agricultural activities in Morocco. In total, 59.7% of the farmers surveyed have a high level of education, while the rest are illiterate. Moroccan farmers practice more animal agriculture than vegetable agriculture and confirm that their activities generate 100% of their waste. Only 30% of the farmers surveyed opt for waste recycling by producing compost. Nonetheless, composting has so far been a practice that has not been well addressed by the respondents. The results obtained show that only 10% of farmers know about compost.

However, a high level of acceptance for the hypothetical idea of producing and using compost for agriculture is noted among Moroccan farmers. This acceptance is more likely when farmers are more familiar with compost, its benefits and its production and use methods. In addition, farmers have a high (80%) willingness to produce compost themselves and use it in agriculture. The positive perceptions of farmers and the high level of willingness to produce compost imply that the composting of organic waste should be encouraged by our local authorities. This will alleviate the inappropriate waste disposal, the resulting water and soil pollution, prevent the excessive use of chemical fertilizers and pesticides, reduce the flow of waste to landfills, reduce the purchase of chemical fertilizers and lead to the discovery of the economic benefits of compost such as increased yields

and improved production of organic crops. In fact, the production of compost will thus contribute to the promotion of an ecological management of agricultural waste that meets the requirements of a circular economy.

All the socio-economic, individual and agricultural factors studied have a great influence on farmers' perception and willingness to produce compost except gender, duration of experience and area of cultivated land. We can therefore conclude that making farmers aware of the economical, agricultural, health and environmental benefits of compost production can only increase their willingness to produce and use compost. The introduction of subsidies for the price of raw materials, production and transport costs of compost, as well as the establishment of practice-based extension services, will further increase their willingness to produce and use compost.

The presented paper addressed to scientific researchers, mainly those interested in environmental protection and agricultural waste management. It provides guidance to academics and policy makers at national and international levels on the opportunities and constraints related not only to farmers' acceptance of the idea of compost production but also to their willingness to produce compost themselves. In addition, it can support conservation agriculture policies through action plans to promote the adoption of organic farming practices, including composting. This research can also be consulted in the development and updating of Moroccan guidelines and policies on agricultural waste management.

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