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RESEARCH

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Factors influencing utilization of municipal solid waste compost among urban farmers in western Uganda

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Abstract

Background: Effective management of solid waste is one of the most serious environmental problems confronting urban governments in developing countries due to insufficient financial resources and institutional capacity to provide basic solid waste management infrastructure, impoverished urban populations, low rates and coverage of collection, and rising food consumption rates. Composting has been touted as the most economical solution for reducing organic fraction of urban waste volumes while releasing vital nutrients for the soils. However, there is a paucity of information on utilization and associated factors of urban wastes in Uganda. This study aims to assess the level of utilization of Municipal Solid Waste (MSW) compost produced from Clean Development Mechanism (CDM) plants and associated factors among farmers in Fort Portal and Mbarara Municipalities, western Uganda.

Methods: Data was collected using a cross-sectional survey from 359 and 361 randomly selected farmers in Mbarara and Fort Portal, respectively. A semi-structured questionnaire was employed to collect quantitative data and analyzed statistically using SPSS and STATA statistical programs. Probit model was used to determine factors that influence farmers' decisions to utilize MSW compost as a soil conditioner.

Results: The findings revealed a very low level of utilization in both municipalities, 1.7% in Fort Portal and 2.2% in Mbarara. The results indicated that annual farm income, access to other soil conditioners, experience with the use of fertilizers, membership to a farmers' group and the cost of MSW compost significantly influenced farmers' decision to use MSW compost.

Conclusions: The findings call for government investment in policies aimed at increasing the level of utilization of the MSW compost by improving accessibility to soil conditioners, creating opportunities for maximizing household incomes, farmer-to-farmer experience sharing, dissemination of information through extension programmes and other innovative communication approaches, operationalization of farmers' groups and introduction of subsidy schemes on the price of compost through operational tax waivers in urban areas of Uganda. Finally, to guarantee quality and to improve the adoption of compost generated at the CDM plants, there is a need for research to assess the quality of MSW compost, undertake a supply chain analysis and cost–benefit study and set a price commensurate with the quality, and develop guidelines and rates of application of the MSW compost.

Keywords: MSW compost, Urban areas, Solid waste management

Background

In Sub-Saharan Africa, the urban population is increasing at an astonishing rate (Saghir and Santoro 2018). For example, in Uganda, the urban population has grown

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by about 4.5 million between 2002 (2.9 million) and 2014 (7.4 m) (UBOS 2016) accelerating the amount of waste generation (Aryampa et al. 2019) and the demand for food (Sabiiti and Katongole 2016, 2014). Effective management of municipal solid waste (MSW), especially organic waste is a challenge to many urban areas in Uganda (Komakech 2014a, b). Most solid wastes are burnt, dumped indiscriminately in landfills leading to pollution of the air, soil and water bodies, posing health and livelihood risks to many urban dwellers (Komakech et al. 2014b). Treatment of the organic fraction of the MSW through composting is one feasible and cost-effective method of reducing waste volumes while releasing vital nutrients for the soils of developing countries (Komakech 2014a; Danso et al. 2017; Nigussie et al. 2015; Tweib et al. 2011). According to Tweib et al. (Tweib et al. 2011), composting can be carried out with little capital and operating costs. For example, a recent economic estimation by Romero et al. (Romero et al. 2013) in Spain showed that the production cost of raw compost leachate as fertilizer could be as low as 0.67€ per litre compared to 4.61 € per litre for commercial fertilizer.

There is potential for organic waste and MSW compost utilization and management through urban agriculture in Uganda (Komakech 2014a; Nsimbe et al. 2018). Treatment of MSW is important to reduce the overuse of chemical fertilizers in agriculture since they cause severe pollution of water resources (Diacono and Montemurro 2011; Ojo et al. 2014; Savci 2012; Udeigwe et al. 2015) and a decrease in the amount of soil organic matter (Massah and Azadegan 2016; Roba 2018; Wu et al. 2020). Moreover, results from the annual agricultural survey carried out in 2018 (UBOS 2018) indicate that 77% of the households in Uganda use organic fertilizers (e.g., livestock manure, crop residues and ash) to improve agricultural production. The use of the derived organic compost represents an appropriate win–win waste management strategy and sustainable soil fertility management practice (Kumar et al. 2020; Rogger et al. 2011), especially for farmers in urban areas (Komakech 2014a; Menyuka et al. 2018).

With the aims to address the mounting solid waste management problems in Ugandan municipalities, reduce greenhouse gas emissions from open dumping landfills and use the generated compost as a safe alternative fertilizer for crop production, the Uganda National Environment Management Authority (NEMA) with support from the World Bank and the government of Netherlands initiated a municipal solid waste composting project in 2005 under the Clean Development Mechanism (CDM) in nine municipalities including Mukono, Jinja, Mbale, Soroti, Lira, Mbarara, Kasese, Kabale, and Fort Portal in the first phase of the project (Lederer et al. 2015; Okot-Okumu and Nyenje 2011). As part of the cost-recovery plan, each municipality was expected to generate revenue through the sale of the recyclables such as plastics to urban residents and composts to its farmers. To sustain the functionality of these compost plants, there is a need to understand whether or not urban farmers utilize these MSW compost as a soil conditioner in agricultural production and the factors that influence its utilization. Studies on the use and determinants of use of agricultural technologies (Melesse 2018; Mwangi and Kariuki 2015) and soil fertility improvement (Abebe and Debebe 2019; Ali et al. 2018; Babasola et al. 2018; Nazziwa-Nviiri et al. 2017) have been done in Uganda, Ghana, Nigeria and Ethiopia. These studies have shown that socio-demographic factors (Mwangi and Kariuki 2015; Abebe and Debebe 2019; Babasola et al. 2018) influenced the use of organic fertilizers. In Uganda, previous studies have mostly involved the use of homemade compost mainly from manure and crop residues, kitchen refuse (Nsimbe et al. 2018), chemical fertilizers (Nazziwa-Nviiri et al. 2017) and fecal sludge (Danso et al. 2017). However, to our knowledge, there is limited evidence about the utilization of MSW compost as a soil conditioner in crop production by urban farmers where CDM plants have been established and associated factors in Uganda. Such information is important in guiding investment decisions by farmers and businessmen in MSW compost reuse businesses through the conversion of waste to organic fertilizers, and urban planning. This study aimed to assess the current utilization of the MSW compost from CDM plants in agricultural production and its associated factors among urban farmers in Mbarara and Fort Portal municipalities of Uganda. Urban areas in this study have been defined as those areas under the municipality administration according to the Uganda National Urban Policy (MoLHUD 2017).

Methods

Study area

The study was conducted in Fort Portal and Mbarara Municipalities of western Uganda. These municipalities were purposively selected because both have the highest rates of organic fertilizer use (39.6%) as reported by UBOS (UBOS 2018), have CDM project compost plants, with each plant capable of composting between 2.3–3.5% of the wastes collected per day (NEMA 2017). The mean annual rainfall and mean annual temperature in Mbarara is 832 mm and 21 °C, respectively, and soils are mostly Luvisols and acidic clay loam (Kaizzi 2014; Wortmann and Eledu 1999). Fort Portal, receives a mean annual rainfall of 1310 mm, with a mean temperature of 20 °C (Wortmann and Eledu 1999), and the soils are characterized as Lixic Ferralsols (Wortmann and Eledu 1999; Okello-Oleng et al. 2021).

Sampling design and sample size

A cross-sectional survey was conducted between February and April 2019 to collect primary data from farming household heads or their spouses. All the divisions and villages in the study municipalities were included in the sampling frame. From each village, a list of farmers, generated with the help of local council chairpersons was used as a sampling frame. We determined the sample size for the number of households to participate in the survey using the Krejcie and Morgan (1970) table, covering both MSW compost users and non-users. Individual urban farmers (farmers above 18 years) from each village were randomly selected and interviewed using a semi-structured questionnaire (Nigussie et al. 2015). The questionnaire was pretested with 20 farmers from Fort Portal Municipality and appropriate modifications were made. The questions asked included the socio-demographic characteristics of the household heads such as age in years, gender, educational level, marital status, land size, land ownership, land tenure, farming experience, access to extension services, access to infrastructure, access to credit facilities, engagement in non-farm activities, annual household income from farming, farmer experience with compost, number of household members and access to other soil conditioners (e.g., livestock manure, crop residues and ash). During the interview process, individual farmers were asked whether or not they utilized MSW compost in their farms. Furthermore, farmers were asked whether or not they were willing to pay for MSW compost and cost per Kg they were willing to pay for such compost. Field observations and discussions with key informant respondents (17 from Fort Portal and 32 from Mbarara) were used to supplement the household interviews.

Study variables

The dependent variable in the study was the level of utilisation of the MSW compost by farmers (1 if utilizing MSW compost, 0 otherwise, Table 1). The independent variables were chosen based on previous studies (Abebe and Debebe 2019; Babasola et al. 2018; Akpan et al. 2012; Huang and Karimanzira 2018; Zhou et al. 2010) and they included socio-demographic factors (e.g., gender, age, marital status, level of education, number of people in the household, farming experience, access to extension services, access to good infrastructure, access to credit facilities, access to markets, membership of farmer association, engagement in non-farm activities, land ownership, farm size, the land tenure system, level of income, access to other soil conditioners (e.g., livestock manure, crop residues and ash), experience in the use of compost, willingness to take part in compost making and cost per Kg of compost the farmer was able to pay.

Data analysis

Primary data was entered into Excel and imported into IBM SPSS version 25 and STATA version 14. Descriptive statistic using percentages was used to express the level of utilization of MSW compost. A probit regression model was used to analyse factors that influence respondents' utilization of MSW compost. Multicollinearity among the explanatory variables used in the model was tested using correlation matrices (Nigmatullin 2008). We determined the statistical significance at a p-value ≤ 0.05. In the probit model, the categorical (usually dichotomous) dependent variable was modelled as a linear (or log-linear) function of a combination of explanatory variables (Noreen 1988). The probit model assumes that while we only observe the values of 0 and 1 for the variable Y, there is a latent, unobserved continuous variable Y* that determines the value of Y (Sebopetji and Belete 2009). The probit model was preferred over the logit model because it includes believable error term distribution as well as realistic probabilities (Nagler 1994). The Probit model is specified as follows:

Let us suppose Yi is a binary response variable with only two possible outcomes (1 if the farmer is utilizing MSW compost and 0 otherwise).

Consider also a vector of independent variables xi which is assumed to influence Yi.

Then the probit model takes the form:

$$\Pr\ (Y_i = 1|\, x_i)\ = F\left(\beta' x_i\right)\ =\ \Phi\left(\beta' x_i\right) \tag{1}$$

where Pr denotes the probability that an individual uses compost or not, Y_i is the binary choice variable representing use and Φ is the cumulative distribution function of the standard normal distribution. β is a vector of unknown parameters.

It is assumed that the latent variable Y_i^* can be specified as follows:

$$Y_i* = \beta_0 + \sum_{n=1}^{N} \beta_n x_{ni} + u_i \tag{2}$$

And that:
$Y_i = 1$ if $Y^* > 0$.
$Y_i = 0$ otherwise.

where x_i represents a vector of explanatory variables, u_i is a random disturbance term, N is the total sample size, and β

Table 1 The description of the variables used in the study and their expected signs

Variable	Description	Definition and unit	Expected sign	References
Dependent variable	Utilization of MSW compost in percentage	1 if utilizing MSW compost 0, otherwise		
Independent variable				
Gender	Gender of household head	1 if the household head (HH) is male, 0 if otherwise	±	Abebe and Debebe 2019; Mukai 2017)
Age	Age of the household head (in years)	1 if less than 18, 2 for18-36, and 3 for greater than 36	-	Zhou et al. 2010; Martey et al. 2014; Li et al. 2020)
Marital status	Marital status of household head	1 if couple; 0 otherwise	±	Ali et al. 2018; Mensah et al. 2018)
Education	Level of education of the household head	0 for illiterate, 1 for primary, 2 for secondary and 3 for tertiary	±	Mwangi and Kariuki 2015)
Household size	Number of people in the household	Number (1 for less than 3, 2 for 3–6, 3 for greater than 6)	±	Ullah et al. 2018)
Extension services	Access to extension services	1 if HH has access to extension services, 0 otherwise	+	Abebe and Debebe 2019; Udimal et al. 2017)
Infrastructure	Access to infrastructure (roads, storage areas etc.)	1 if HH has access, 0 otherwise	+	Assefa and Gezahegn 2009)
Credit facilities	Access to credit facilities	1 if has access, 0 otherwise	+	Abebe and Debebe 2019; Udimal et al. 2017)
Market	Access to market for produce from farm	1 if has market, 0 otherwise	+	Assefa and Gezahegn 2009)
Farmer association	Membership of farmers' association	1 if HH is a member, 0 otherwise	+	Martey et al. 2014; Mensah et al. 2018)
Income	Annual income from farming in Uganda shillings	1 if less than 200,000, 2 for 200,000–400,000 and 3 if greater than 400,000	+	Huang and Karimanzira 2018)
Non-farm activities	Engaged in non-farm activities	1 if the household is engaged in non-farm activities, 0 otherwise	+	Mwangi and Kariuki 2015; Ullah et al. 2018)
Farming experience	Farming experience (years)	1 for less than 5, 2 for 5–10 and 3 if greater than 10	+	Huang and Karimanzira 2018; Mensah et al. 2018)
Land ownership	Land ownership	1 if land is available, 0 otherwise	+	Huang and Karimanzira 2018)
Land size	Total size of the farmland (acres)	Acres (1 for less than 2, 2 for 2–4 and 3 for greater than 4 acres)	+	Huang and Karimanzira 2018)
Land tenure	Household land tenure system	Land tenure (1 for customary, 2 for freehold, 3 for leasehold and 4 for Mailo)	+	Nambiro and Okoth 2013)
Access to soil conditioner	Household access to soil conditioner	1 if HH has access, 0 otherwise	+	Mwangi and Kariuki 2015)
Experience of compost	Experience with compost fertilizer use in years	1 if the HH applied compost, 0 otherwise	+	Mukai 2017)
Cost at which farmer is willing to pay for compost	Cost at which farmer is willing to pay for use of compost as a soil conditioner	1 if willing to contribute money, 0 otherwise	+	Mwangi and Kariuki 2015)
Price of compost	Cost of compost per kilogram	1 for less than 100, 2 if 100–200, 3 for 200–500 and 4 for $\geq$ 500	+	Nazziwa-Nviiri et al. 2017; Akpan et al. 2012)

is a vector of unknown parameters to be estimated by the method of maximum likelihood.

Model specification;

where,

Yi = is the probability of utilization of MSW compost (1 if the farmer is utilizing MSW compost, 0 otherwise); X1,

$$\begin{aligned} Yi = &\beta 0 + \beta 1X1 + \beta 2X2 + \beta 3X3 + \beta 4X4 + \beta 5X5 + \beta 6X6 + \beta 7X7 + \beta 8X8 + \beta 9X9 + \beta 10X10 + \beta 11X11 \\ &+ \beta 12X12 + \beta 13X13 + \beta 14X14 + \beta 15X15 + \beta 16X16 + \beta 17X17 + \beta 18X18 + \beta 19X19 + \beta 20X20 + ui \end{aligned} \quad (3)$$

gender of household head (male = 1, otherwise 0); X2, age of the household head (year); X3, marital status (1 if couple, 0 otherwise); X4, education of household head; X5, household size; X6, access to extension services; X7, access to infrastructure; X8, access to credit facilities; X9, access to market for produce; X10, membership of farmer association; X11, annual income from farming in Uganda shillings; X12, engagement in non-farm activities; X13, farming experience; X14, land ownership (1 if land is available, 0 otherwise); X15, total size of farmland in acres; X16, household land tenure system; X17, household access to other soil conditioners (1 if household has access, 0 otherwise); X18, experience with compost fertilizer use in years (1 if the household applied compost, 0 otherwise); X19, cost at which farmer is willing to pay for use of MSW compost as a soil conditioner (1 if willing to contribute money, otherwise 0); X20, cost per kilogram of compost; β0 is the regression coefficient and ei is random error term. The model estimates marginal effects of an explanatory variable on the expected value of the dependent variable and the coefficients are more informative and useful for policy decision making (Anang 2016).

The marginal effects are estimated by differentiating Eq. (1) with respect to x_i according to Greene (Greene 2000).

$$\frac{\partial y}{\partial x} = \phi\left(\beta' x_i\right)\beta_i \tag{4}$$

where ϕ represents the probability density function of the standard normal distribution.

Results

Socio-demographic characteristics of respondents and utilization of MSW compost

The study revealed that among the study participants in Fort Portal, the majority were females (56.5%), were aged above 36 years (56.2%), were married (71.5%), had no experience in composting (73.7%), had access to extension services (67.6%), had access to other soil conditioners (60.1%), had access to infrastructure (good roads and storage, 94.2%), had access to credit facilities (74.2%) and markets (93.6%), were engaged in non-farm activities (78.8%), owned land (90.3%), and had less than two acres of land (57.6%). Nevertheless, only 35.5% were members of farmers' associations. In Mbarara, the majority were males (51.8%), married (65.7%), had secondary level education (34.4%), had a household size of 3–6 persons (45.5%), had access to a soil conditioner (62.7%), had access to extension services (60.4%), had access to good infrastructure (87.5%), had access to credit facilities (70.8%) and markets (83.6%), had prior experience in composting (44.0%), earned an annual income of less than 200,000 Uganda shillings (56 US dollars) from farming (46.8%), were involved in non-farm activities (66.6%) and owned land (77.2%) of less than two acres (33.1%). Only 30.6% were members of the farmer associations and had a farming experience of more than 10 years (24.6%) (Table 2). Also, in this study, only 1.7% of the farmers in Fort Portal municipality utilized MSW compost compared to 2.2% of the farmers in Mbarara municipality.

Factors associated with utilization of MSW compost

The probit regression results of factors influencing farmers' utilization of MSW compost in Fort Portal and Mbarara municipalities are presented in Table 3. The likelihood ratio chi-square (LR Chi^2) for the model was statistically significant at 1% level of significance, which revealed the model had good explanatory power. The validity of the Probit model in estimating utilization of MSW compost is consistent with a related study from Ghana (Danso et al. 2017). Results from the Probit regression model showed that five out of the 20 variables included in the model were positively significant in influencing the utilization of MSW compost in Mbarara, whereas four variables were positively significant in influencing farmers' decision to utilize MSW compost in Fort Portal (Table 3). In Fort Portal, the factors that were positively significant in influencing farmers' decision to use MSW compost were the level of income from farming activities, access to other soil conditioner, the experience a farmer had in using a soil conditioner. The cost of compost was negatively significant in influencing farmers' decision to use MSW compost. However, in Mbarara, the level of income from farming activities, access to other soil conditioners and the experience a farmer had in using a soil conditioner significantly and positively influenced farmers' decision to use MSW compost. Membership of a farmer association and the cost per Kg of compost were the factors that significantly and negatively influenced the decision to use MSW compost (Table 3).

Discussion

The level of utilization of CDM compost found in our study (1.7% for Fort Portal Municipality and 2.2% for Mbarara Municipality) were much lower than what was reported (25%) for municipal solid waste compost in urban and peri-urban areas of Accra, Ghana (Danso et al. 2006). The generally low utilization of the compost in urban areas might be explained by constraints associated with urban compost use (e.g., poor quality of compost including broken bottles and polythene, price and transportation costs, high water requirements of plants following compost application and absence of markets for organically produced crops), negative perceptions

Table 2 Socio-demographic characteristics of the study participants and utilization of MSW compost in Fort Portal and Mbarara municipalities, western Uganda, 2018 (n = 359 for Mbarara and 361 for Fort Portal)

Variable	Description	Mbarara		Fort Portal	
		N	Frequency (%)	N	Frequency (%)
Gender of household head	Female	173	48.2	204	56.5
	Male	186	51.8	157	43.5
Age (years)	Below 18	3	0.8	1	0.3
	18–36	200	55.7	157	43.5
	Above 36	156	43.5	203	56.2
Marital status	Single	73	20.3	57	15.8
	Married	236	65.7	258	71.5
	Divorced/Separated	12	3.3	20	5.5
	Widowed	38	10.6	26	7.2
Education	No formal education	32	8.9	36	10
	Primary	106	29.5	92	25.5
	Secondary	123	34.3	188	52.1
	Tertiary	98	27.3	45	12.5
Family size	Below 3	99	27.6	51	14.4
	3 to 6	163	45.4	158	43.8
	Above 6	97	27	151	41.8
Access to extension services	Yes	142	39.6	244	67.6
	No	217	60.4	117	32.4
Access to infrastructure	Yes	314	87.5	340	94.2
	No	45	12.5	21	5.8
Access to credit facilities	Yes	254	70.8	268	74.2
	No	105	29.2	93	25.8
Access to market for produce	Yes	300	83.6	338	93.6
	No	59	16.4	23	6.4
Membership of farmer association	Yes	110	30.6	128	35.5
	No	249	69.4	233	64.5
Annual income from farming in Uganda shillings	Less than 200,000	168	46.8	37	10.2
	200,000–400,000	137	38.2	158	44.6
	Greater than 400,000	54	15	163	45.2
Engagement in non-farm activities	Yes	239	66.6	284	78.7
	No	120	33.4	77	21.3
Farming experience	Less than 5	138	38.4	97	26.9
	5 to 10	133	37	129	35.7
	Above 10	88	24.6	135	37.4
Land ownership	Owns land	277	77.2	326	90.3
	Does not own land	82	22.8	35	9.7
Total size of farmland in acres	Below 2	119	33.1	208	57.6
	2 to 4	101	28.1	124	34.3
	Above 4	75	20.9	26	7.2
	Not applicable	64	17.8	3	0.8
Household land tenure system	Customary	145	40.4	48	13.3
	Freehold	138	38.4	213	59
	Leasehold	18	5	70	19.4
	Mailo	6	1.7	30	8.3
Household access to soil amendment	Yes	225	62.7	217	60.1
	No	134	37.3	144	39.9
Experience with compost fertilizer use in years	No experience	158	44	266	73.7

Table 2 (continued)

Variable	Description	Mbarara		Fort Portal	
		N	Frequency (%)	N	Frequency (%)
	Less than 1	39	10.9	35	9.7
	1 to 3	66	18.4	22	6.1
	Above 36	64	17.8	38	10.5
Cost at which farmer is willing to pay for use of soil amendment	Yes	203	56.5	232	64.3
	No	156	43.5	129	35.7
The price per kg a farmer can pay	Less than 100	130	36.2	124	34.3
	100–200	44	12.3	100	27.7
	Greater than 200	17	4.7	7	1.9
	Should be given for free	13	3.6	1	0.3
	Not applicable	155	43.2	129	35.7
Utilization of MSW compost	Yes	8	2.2	6	1.7
	No	351	97.8	355	98.3

Table 3 Probit regression results of factors influencing farmers' decision to use MSW compost in Fort Portal and Mbarara municipalities, Uganda

Independent variables	Fort Portal				Mbarara			
	Coefficient	Standard Error	P>|z|	Marginal effect (dy/dx)	Coefficient	Standard Error	P>|z|	Marginal effect (dy/dx)
Gender of household head	0.256	0.244	0.294	0.03	0.234	0.246	0.343	0.027
Age of household head	− 0.073	0.127	0.567	− 0.008	− 0.036	0.129	0.78	− 0.004
Marital status of household head	− 0.019	0.168	0.912	− 0.002	− 0.016	0.168	0.924	− 0.002
Level of education	− 0.001	0.132	0.993	< 0.001	− 0.027	0.132	0.841	− 0.003
Family size	0.152	0.144	0.292	0.018	0.166	0.146	0.257	0.019
Access to extension services	0.168	0.303	0.581	0.019	0.232	0.307	0.449	0.027
Access to infrastructure	0.517	0.554	0.351	0.061	0.522	0.561	0.352	0.061
Access to credit facilities	0.418	0.315	0.185	0.049	0.399	0.317	0.208	0.046
Market for produce	− 0.114	0.503	0.821	− 0.013	− 0.123	0.506	0.807	− 0.014
Member of farmer association	− 0.569	0.316	0.072	− 0.067	− 0.648	0.325	**0.047**	**− 0.075**
Level of income from farming in Uganda shillings	0.314	0.145	**0.031**	**0.037**	0.306	0.147	**0.038**	**0.036**
Engaged in non-farm activities	0.344	0.261	0.186	0.04	0.344	0.263	0.191	0.039
Farming duration years	0.064	0.172	0.709	0.008	0.089	0.174	0.605	0.01
Land ownership	0.478	0.434	0.270	0.056	0.557	0.447	0.213	0.065
Size of land in acres	0.099	0.168	0.557	0.012	0.169	0.177	0.340	0.019
Land tenure	0.168	0.128	0.895	0.002	− 0.004	0.129	0.973	0.010
Access to soil conditioner (Other than the MSW compost)	1.655	0.347	**0.000**	**0.194**	1.639	0.35	**0.000**	**0.191**
Experience with compost fertilizer (time of utilization in years)	0.369	0.973	**0.000**	**0.043**	0.369	0.098	**0.000**	**0.043**
The cost per kg of compost	− 1.394	0.14	**0.000**	**− 0.164**	− 1.41	0.142	**0.000**	**− 0.164**
Market for produce	− 0.114	0.503	0.821	− 0.013	− 0.123	0.506	0.807	− 0.014
Observations	358				359			
Log likelihood	− 76.64				− 74.77			
LR Chi2 (19)	336.55***				334.57***			
Prob > chi2	0.001				0.001			
Pseudo R2	0.69				0.68			

dy/dx[b] = Marginal effect after Probit evaluated at population average and ***Indicate significance at the 1% level of significance. m p values are in bold

about compost as reported by Danso et al. (2006) among urban and peri-urban farmers in Accra, Ghana, and a lack of awareness about the benefits of compost for soil fertility (Dandeniya and Caucci 2020). From a practical point of view, these findings as well as our study emphasize the need to strengthen extension programmes and training on compost use, provision of long-term compost price subsidy program through operational tax waivers and provision of transport to resource-constrained smallholder farmers especially in areas with weak commercial fertiliser distribution networks as already being implemented in Western Kenya (Makau et al. 2016) and improving quality through compost segregation in urban areas of Uganda.

The Probit regression model showed how the significant factors would predict the future use of the MSW compost by farmers. The findings indicated that a unit increase in a farmer joining a farmer association in Mbarara leads to a 7.5% decrease in the probability of farmers' decisions to use MSW compost, contrary to the expected benefits of group membership, where farmers are empowered to achieve higher yields. This is contrary to a study carried out in Nepal (Kumar et al. 2020) where membership to cooperative associations positively influenced farmers' decision to use improved agricultural technologies and extension services. The study also showed that a unit increase in the level of income from farming increases the chances of a farmer using MSW compost by 3.7% and 3.6% in Fort Portal and Mbarara, respectively. A farmer earning from his produce is motivated to invest in productivity improvement technologies (e.g., purchase of inputs), resulting in improved utilization of compost (Singh et al. 2016). Furthermore, a unit increase in accessibility to other soil conditioners lead to a 19.4% and 19.1% increase in the likelihood of farmers using MSW compost in Fort Portal and Mbarara, respectively. This means that farmers who have access to other types of soil enhancers have a high likelihood of using MSW compost. However, a previous study conducted in Mbarara district in 2013 shows that farmers are likely to abandon the use of fertilizers because of ease of accessibility to livestock dung (Kasirye 2013). This study also showed that an increase in the price of the MSW compost would lead to a 16.4% reduction in level of farmer's decision to use MSW compost in both Fort Portal and Mbarara municipalities. This is because most farmers already had a fixed amount of money (fee set by the municipal council at the launch of the compost plants) they were willing to pay for the MSW compost. Therefore, any increase in the amount beyond the municipal price may lead to a decrease in its use. This finding is similar to studies of Blessing et al. (2010) in Imo State, Nigeria which found that the price of fertilizer was a significant determinant of a farmer's decision to adopt or not to adopt the use of fertilizer. Finally, this study also revealed that the experience a farmer had in using any soil conditioner had a positive significant relationship with farmers' decision to use MSW compost. This finding is consistent with studies conducted in Brazil (Morello et al. 2018) where the level of experience with fertilizers had a positive and significant effect on fertilizer adoption. An increase by a year of experience in the use of fertilizers by a farmer leads to a 4.3% increase in the level of farmer decision to use MSW compost in both Fort Portal and Mbarara municipalities. Farming experience increases the likelihood of farmers using the compost as experienced farmers have much knowledge and also information about the success and failure of using fertilizers than farmers with less experience.

Conclusion and policy implications

This study explored the level of utilization and the factors affecting the farmers' decision to use MSW compost from the CDM plants in two urban areas of Uganda. Results showed that the level of utilization of MSW compost in both municipalities is generally low. Results obtained from the probit model showed that annual farm income, access to a soil conditioner, experience with the use of fertilizers positively influenced farmers' decision to use MSW compost while the price of MSW compost and membership in a farmers' group negatively influenced farmers' decision to use MSW compost. The negative influence of group membership on the use of MSW compost in Mbarara, should be a concern to policymakers in a country that currently invests in agricultural extension through groups such as that under the Operation Wealth Creation Scheme. Overall, the findings of this study suggest the need for government to create an enabling environment by investing in policies aimed at improving accessibility to soil conditioners, creating opportunities that maximize income from households, interventions focused on the farmer-to-farmer experience sharing, improved dissemination of information through extension programmes and other innovative communication approaches harnessing the benefits of digital tools, and long-term subsidy schemes for the price of compost through operational tax waivers and provision of transport for farmers in urban areas of Uganda. Finally, to guarantee quality and to improve adoption of compost generated at the CDM plants in Uganda, there is a need for research on supply chain analysis and CDM plant operators to invest in research on the quality of MSW compost generated at their facility, conduct cost–benefit analysis of compost application and therefore set a price commensurate with quality, and develop guidelines and rates of application of the MSW compost. Furthermore, a market research using the new product

design (Urban and Hauser 1993) should be conducted focusing on farmer perception, preference and adaptive conjoint measurement (tradeoff) analysis. This analysis will help the CDM plant operators to tailor their products and services to different customer segments in quality (price setting, etc.) and therefore address the issue of famer perception about fertilisers.

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Authors' contributions
All authors have participated sufficiently in the work and take responsibility for the content, including participation in the concept, design, analysis, writing, or revision of the manuscript. Conception and design of study: KJK, EO, GMM, JCWO. Acquisition of data: KJK, GMM. Analysis and/or interpretation of data: KJK, EO, GMM. Drafting the manuscript: KJK, GMM. Revising the manuscript critically for important intellectual content: KJK, EO, GMM. Approval of the version of the manuscript to be published: KJK, JCWO, EO, GMM. All authors read and approved the final manuscript.

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Availability of data and materials
Data and materials for this study are available from the corresponding author upon request.

Declarations

Ethics approval and consent to participate
The ethical approvals were obtained from Gulu University Research and Ethics Committee (GUREC) and the Uganda National Council for Science and Technology (UNCST), prior to the data collection. Permission was also obtained from Fort Portal and Mbarara Municipal Council authorities before commencement of the study. Participation in the study was voluntary and written consent was obtained from participants prior to the interviews and all data were collected through their consents.

Consent for publication
Not applicable.

Competing interests
Not applicable.

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