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FARMERS' PERCEPTION OF SOIL: IMPLICATIONS FOR SOIL CONSERVATION AND SUSTAINABLE AGRICULTURE IN THE UK

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Abstract

We identify UK farmers' perception of soil, awareness of soil in terms of how they describe it, their awareness of its benefits other for than crop production, their familiarity with soil conservation, and their opinions on soil protection and the value of organic fertilizers. Data were collected with the aid of social media using both Twitter and electronic mail to distribute a survey link to farmers. UK yellow pages, Natural England directory and Twitter were used to search for farms. Data were analysed using SPSS version 22.0 statistical software and Wordle. Chi square was used to test for relationships between variables at 95% confidence level ($p<0.05$), while Phi and Cramer's V were used to measure strength of association for significant relationships. Results showed that farmers' describe soils in abstract, scientific, physical attribute and functional terms. Awareness of soil benefits other than crop production was significantly related to age, and farm ownership. Educational level was significantly related to familiarity with soil conservation, and opinion on whether soil should be protected like other natural resources. The implications of these results for soil conservation and sustainable agriculture are discussed and used as, the basis for policy recommendations.

Keywords: Anaerobic digestion (AD), Ethnopedology, Soil conservation, Sustainable agriculture, Perception

1. INTRODUCTION

Soils are an important component of the environment. They provide habitat for biodiversity, platform for buildings, recreation, organic materials, food and feed; they support agricultural production, water storage and nutrient cycling; they regulate water quality and supply, climate and, atmospheric gases; and they make up part of our natural heritage (Haygarth and Ritz 2009). Some anthropogenic and natural processes reduce the capacity of soils to deliver these functions. These include: soil erosion, population growth, intensified agriculture, deforestation, and inorganic fertilizer use. These processes directly and indirectly cause changes in the biological, chemical and physical properties of soils, leading to a global decline in soil quality (Tesfahunegn *et al.* 2011). While soil erosion is widely recognised as a major factor in soil degradation and decline in soil quality (Hannam and Boer 2004; Morgan 2005), population growth and resulting food security concerns have promoted the need to conserve soils at the international, regional and national scale (Hannam and Boer 2004; Khanif 2010; Schneider *et al.* 2010; Nkegbe 2013; Sudha 2015). Population growth decreases available agricultural land through development in the form of soil sealing. It also increases pressure on available agricultural land for food production, thereby leading to intensified agricultural production. Intensification of agricultural production encourages the use of inorganic fertilizers to maintain soil fertility, however, their long term impact on the environment mainly water contamination which affects human health make their use less ideal for soils (Schiermeier 2013).

Soil conservation efforts have taken the form of land policies to encourage better farming practice such as zero tillage (Schneider *et al.* 2010), less inorganic fertilizer use (Schiermeier 2013; Karltun *et al.* 2013) and those non-agricultural practices that expose soils to degradation such as deforestation. Zero-tillage involves crop production on undisturbed soils using specialised machinery and weed control with herbicides. In this way the soil structure remains undisturbed and susceptibility to erosion is reduced. Legislation and policies to enforce soil conservation within the UK, such as *code for good agricultural practice for soil*, are weak and are hardly enforcing on farmers (Ingram and Morris 2007). At the European level, the *Thematic Strategy for Soil Protection* was adopted in 2006 to encourage soil conservation among member states, but a proposed soil directive for the EU was withdrawn in May 2014. However, the Seventh Environment Action Programme which came into action in January 2014, acknowledges the severity of soil degradation and set a target of sustainable soil management by 2020 (EC 2015). Central to this programme is the minimisation of soil erosion and increase in organic matter content of soils. At the international level, IUCN Resolution of 2000 on the Sustainable Use of Soils is the main legislative framework that has guided the development of soil conservation initiatives (Hannam and Boer 2004). Even though legislation is considered an important tool for soil conservation (Hannam and Boer 2004, Towers *et al.* 2005), it is inadequate to control the rapid rate of soil degradation globally.

The recognition of the inadequacies in policy and legislation for soil conservation has led to a gradual shift in conservation efforts towards the assessment of knowledge of farmers about soils (Ingram *et al.* 2010; Karltun *et al.* 2013; Schiermeier 2013; Rushemuka *et al.* 2014), and their soil management practices (Nkegbe 2013; Kings 2014; Tesfaye *et al.* 2014; Sudha 2015). This shift in soil conservation efforts recognises farmers as primary players in the conservation of soils. Assessing farmers' knowledge of soil is necessary for the development of more effective policies and soil management initiatives (Tesfahunegn *et al.* 2011). This approach is similar to ethnopedology, which is the study of local knowledge of soil (WinklerPrins and Sandor 2002), and the main difference is that some studies have been more focused on farmers' soil management practices and therefore lack the full integration of topics covered in ethnopedology. This research however, not only looks at farmers'

knowledge of soil and its benefits, but also their knowledge of soil conservation, the need to protect soils, and organic fertilizer use. Building on the principles of ethnopedology, this research aims to relate farmers' description of soils to scientific information, and furthermore to relate farmers' knowledge to their individual demographic characteristics. The study also builds on earlier reports of Duruiheoma *et al.* (2014) on the need to raise awareness on the benefits of AD in the UK to encourage its uptake among farmers, but for this to be effective its critical to understand farmers' perceptions of soils so that messages can be framed appropriately. In addition, recommendations on soil management policies, initiatives and conservation efforts are made based on the relationships observed between farmers' demographic characteristics and their knowledge, and opinions.

2. METHODOLOGY

2.1 Study participants

A total of 283 UK farmers participated in the survey used for this research. The distribution of respondents across England, Scotland, North Ireland and Wales is presented in Figure 1. The points on the map represent the approximate location of the counties where participating farms are located. These points do not however, include the county location of all 283 farmers that participated in the survey as already reported in Duruiheoma *et al.* (2015a).

2.2 Recruitment process and measurements

The process of farmers' recruitment has been reported in detail in Duruiheoma *et al.* (2015a). In brief, it involved the use of the farm directory of Natural England, the Yellow Pages business directory for the UK, e-mail communication and Twitter. The directories and Twitter were used to search for farms, while both the e-mail account and Twitter were used to distribute the survey link to farmers. Twitter proved to be a very useful tool for the survey process. Open and closed questions were included in the survey questionnaire. Table 1 shows the dependent variables used. The independent variables and their units have been presented in Duruiheoma *et al.* (2015a); they include: gender, age, farm type, education, farm ownership, farm size (in hectares) and farm topography.

Table 1. Dependent variables used in survey questionnaire

Variables	Units
What 4 key words would you use to describe soils?	Open-ended
Are you aware of the benefits of soils other than crop production?	1 'Yes', 2 'No'
How familiar are you with soil conservation?	1 'Very familiar', 2 'Familiar', 3 'Heard of but could not explain', 4 'Never heard of'
Should soils be protected like other natural resources?	1 'Yes', 2 'No'
Do you think organic fertilizers are good for soils?	1 'Yes', 2 'No'

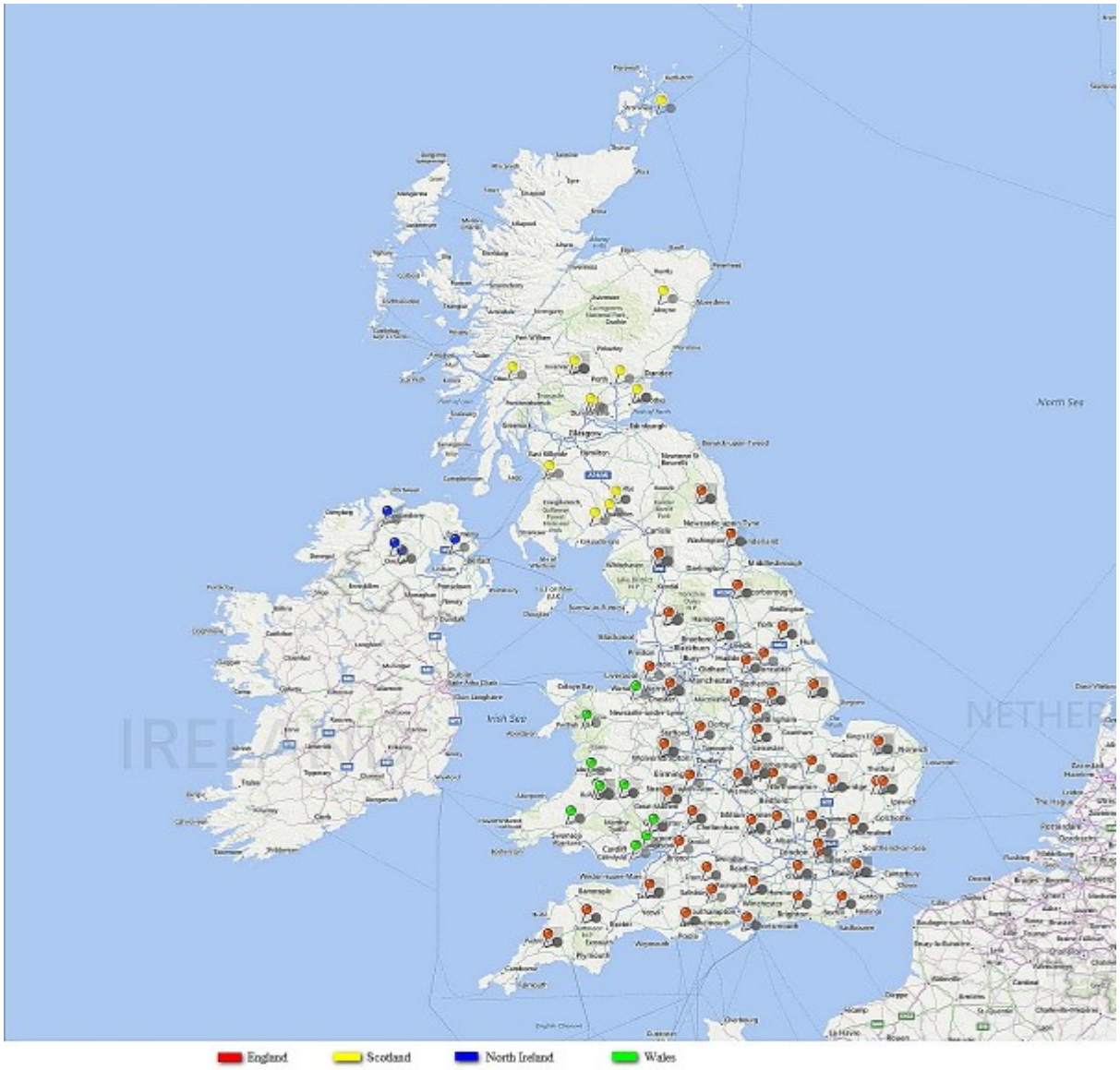

Figure 1. Distribution of participating farms across the UK
© Duruiheoma *et al.* (2015a)

2.3 Data analysis

Data were analysed using SPSS statistical software version 22.0. Analysis involved testing for relationships between dependent and independent variables (excluding topography), and also within the dependent variables at 95% confidence level ($p<0.05$). Phi and Cramer's V values were used to measure the significant relationships observed, and basic Chi square assumptions using SPSS were observed (Field 2009; Pallant 2013). For the open ended question on soil description, Wordle was used to count words and create 'word clouds' at wordle.net. The 'word clouds' are presented as figures in the result section of this report. Descriptive statistics are used to present the response distribution for closed questions.

3 RESULTS

3.1 Response distribution of variables

Table 2 shows the response distribution of independent variables. Male farmers were more frequent respondents than female. Percentage responses were distributed fairly evenly across age groups with the exception of '61-70' and 'above 70'.

Table 2. Independent variable distribution
© Duruiheoma *et al.* (2015a)

Variables	Options provided	Response percentage
Gender	Female	30.4%
	Male	69.6%
Age	Less than 30	21.9%
	30-40	22.9%
	41-50	24.4%
	51-60	20.8%
	61-70	9.3%
	Above 70	0.7%
Farm type	Arable	16.0%
	Livestock (dairy and meat)	42.3%
	Mixed (arable and livestock)	33.8%
	Horticulture	4.6%
	Other	13.5%
Level of education	GCSE or equivalent	8.4%
	A levels or Equivalent	9.1%
	Diploma	23.6%
	Degree	42.9%
	Postgraduate degree	12.4%
	Other	3.6%
Farm ownership	Owner	55.4%
	Manager	18.2%
	Tenant	11.1%
	Other	15.4%
Farm size	Less than 30ha	15.5%
	30-60ha	14.4%
	61-90ha	10.8%
	Above 90ha	59.4%
Farm topography	Upland	18.5%
	Lowland	81.5%

The least common farm type in the categories provided was horticultural. Responses also show that more than 70% of farmers surveyed had at least a Diploma level of qualification.

Tenancy was the least common type of farm ownership identified at 11.1%. The table also shows that more than 70% of farms surveyed were larger than 60 hectares (ha). Most farms surveyed were on lowland, located mainly in the Southern part of the UK (Figure 1).

Table 3. Dependent variable distribution

Variables	Options provided	Response percentage
Are you aware of the benefits of soils other than crop production?	Yes	83.8%
	No	16.2%
How familiar are you with soil conservation?	Very familiar	25.3%
	Familiar	56.8%
	Heard of but could not explain	15.3%
	Never heard of	2.6%
Should soils be protected like other natural resources?	Yes	92.7%
	No	7.3%
Do you think organic fertilizers are good for soils?	Yes	91.4%
	No	8.6%

Responses revealed that most of the study participants claim to know the benefits of soils other than crop production. Although participants were not asked to mention other benefits of soils they are aware of, their responses suggest strongly that most of the farmers surveyed may have some information on the various functions of soil discussed in the Introduction. In terms of soil conservation, more than 80% of participants were at least familiar with the concept. This percentage also represents those participants that believe they can explain what soil conservation means. Similarly, a large majority of participants agree that soils should be protected like other natural resources, which is in line with the level of awareness of the other functions of soils and soil conservation. The use of organic fertilizers also gained wide support from participants.

3.2 Soil descriptions

A total of 213 (75.3% of all participants) farmers responded to the question on four key words to describe soils, although this percentage declined slightly and progressively from the first to fourth key word. 208 participants provided first and second key words, 204 first to third key words, and 194 provided the complete four key words. The responses show a diversity of words that can be used to describe soils. Figure 2 shows the common first key words used to describe soil. The words used here are more abstract with words like ‘essential’ being the most popular first key word. Other popular key words, like ‘alive’, ‘vital’, ‘heavy’ and ‘fertile’ also suggest a broad view of soils shared by the farmers. The second (Figure 3) and third (Figure 4) key words used indicated that participants have some ‘scientific’ knowledge of soils with ‘clay’, ‘humus’, ‘structure’, ‘nutrients’, ‘organic’ and ‘pH’ more common. A closer look at Figure 3, also shows that most of the common second key words used are associated with soil physical characteristics. In addition to showing some ‘scientific’ knowledge about soil, the third key words covered both soil functions and abstract descriptions.

The fourth key words (Figure 5) consisted mainly of a mixture of abstract and scientific terms with words like ‘loam’, ‘productive’, ‘structure’, ‘organic matter’, ‘essential’ and ‘complex’ being most

popular. Overall (Figure 6), the words used to describe soil fall into four categories, namely: abstract, scientific, physical soil attributes, and soil function.

Figure 2. First key words used to describe soils

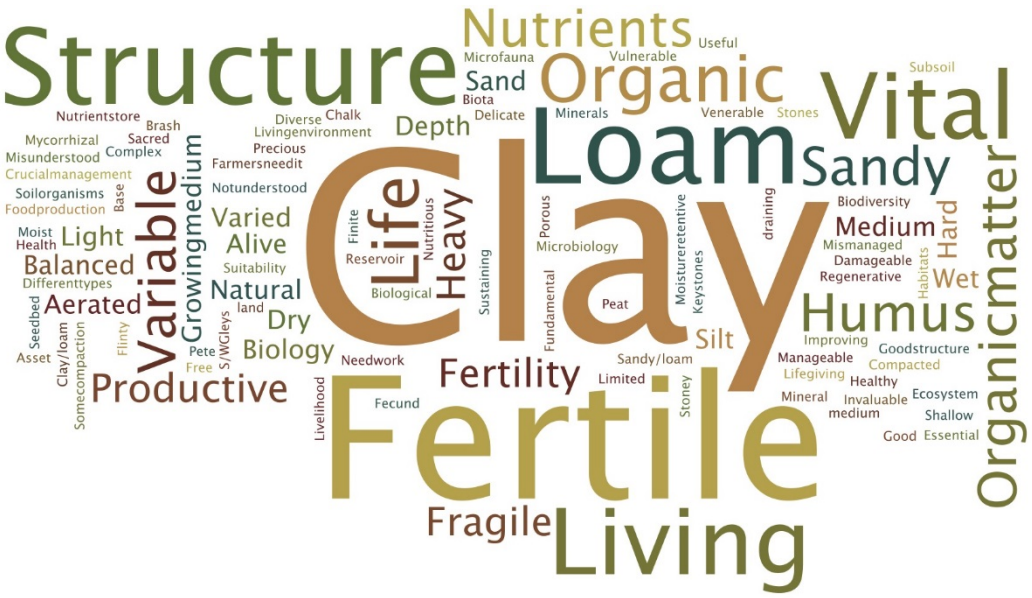

Figure 3. Second key words used to describe soils

3.3 Interactions between variables

Table 4 shows the results of the test between dependent and independent variables. Gender, farm type and size had no significant relationship with any of the dependent variables. The closest to a significant relationship with gender (p=0.073) was observed on opinion on whether soils should be protected like other natural resources. The results, though not significant, showed that a greater percentage of female participants answered ‘yes’ to the question. A similar relationship was observed with farm size, with the highest percentage of

'yes' coming from participants with farm size between '61-90ha', again this is not significant (p=0.095).
Age has a significant relationship with awareness of the benefits of soils other than crop production (p=0.003), and this association has a small to medium strength (Cramer's V=0.272). The results showed that the percentage of farmers aware of the benefits of soils other than crop production increased progressively with age. Age also showed a near significant relationship with opinion on whether organic fertilizers are good for soil (p=0.068). This result might have been significant if there were more participants in the older age groups.

Figure 4. Third key words used to describe soils

Figure 5. Fourth key words used to describe soils

Figure 6. Overall key words used to describe soils

Level of education showed a significant association with both familiarity with soil conservation and opinion on whether soils should be protected like other natural resources (Table 4) and the strength of association in both cases was medium to large (Cramer's V=0.19 and 0.252 respectively). Percentage familiarity with soil conservation increased with educational level. However, farmers with 'A level or equivalent' were least familiar with soil conservation followed by those with 'diploma'. A similar trend was observed with opinion on whether soils should be protected like other natural resources. The main difference here was that, famers with 'GCSE or equivalent' had the highest 'yes' percentage.

Farm ownership was significantly related to awareness of the benefits of soil other than crop production, with a small to medium strength (Cramer's V=0.252). Results showed that farm owners were more aware of these benefits, followed by tenant farmers.

Table 4. Observed p values for test between dependent and independent variables

Independent Dependent	Gender	Age	Farm type	Level of education	Farm ownership	Farm size
Awareness of the benefits of soils other than crop production	.523	.003*	.330	.216	.002*	.857
Familiarity with soil conservation	.408	.123	.104	.019*	.794	.540
Opinion on whether soils should be protected like other natural resources	.073	.865	.431	.016*	.465	.095
Opinion on whether organic fertilizers are good for soils	.996	.068	.858	.482	.914	.609

*significant relationship

Significant relationships were observed both between awareness of the benefits of soil other than crop production and familiarity with soil conservation, and between opinion on whether soils should be protected like other natural resources and opinion on whether organic fertilizers are good for soils (p=0.0001 and 0.045 respectively). Figure 7 shows that the more familiar farmers are with soil conservation the more likely they are to be aware of the benefits of soils other than crop production and vice versa. The strength of this association is large (Cramer's V=0.508). For opinions on whether soils should be protected like other natural resources against whether organic fertilizers are good, the results showed that participants who agreed with one were more likely to agree with the other, and the association was small to medium, with (Phi value=0.154).

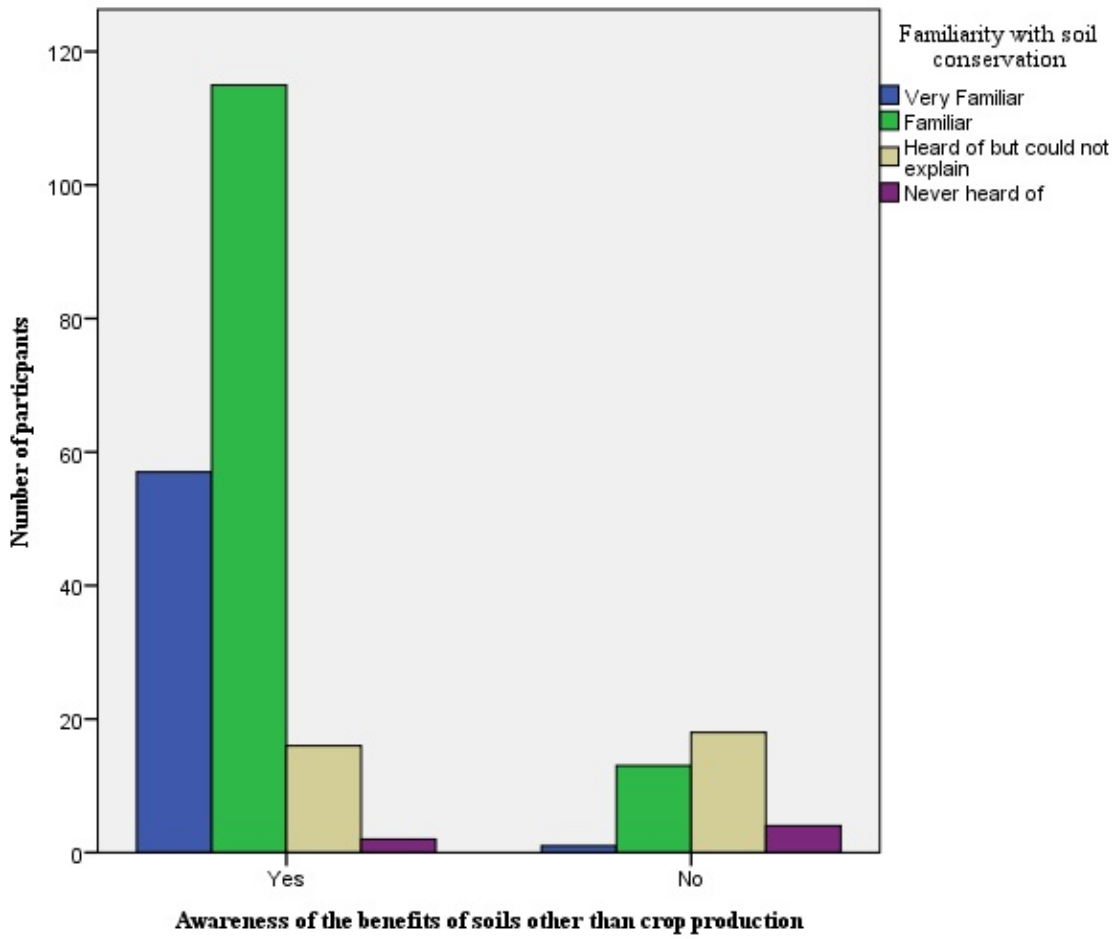

Figure 7. Distribution of responses between awareness of the benefits of soils other than crop production and familiarity with soil conservation

All significant relationships observed in this analysis suggest that the type of associations detected between variables did not happen as a result of sampling or by chance, and similar relationships can be expected from a wider sample of the UK farming population with a 95% confidence level.

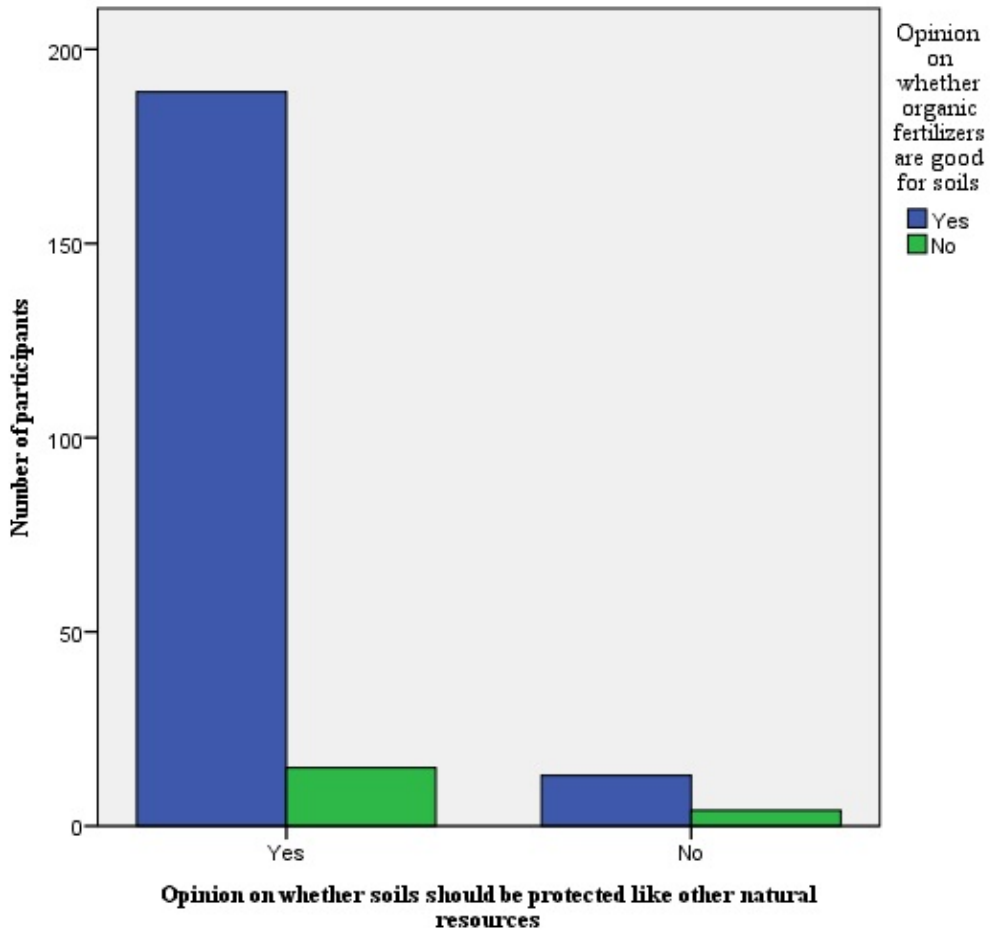

Figure 8. Distributions of responses between opinions on whether soils should be protected like other natural resources and whether organic fertilizers are good for soils

4. DISCUSSION

The description of soils given by farmers in this study suggest that farmers have some knowledge about soils. The study also shows that not only do farmers have a different knowledge of soils from scientists (Ingram *et al.* 2010), but that there is a difference among farmers themselves looking at the number of words used to describe soils. The findings of the study are not limited to differences in the perception of soils among farmers, but also include certain similarities in their perception of soils. This is particularly relevant considering the diversity in the farmers' age groups, educational level, farm type and other independent variables that had significant associations with the dependent variables.

The words used to describe soils, which have been categorised into abstract, scientific, physical, and soil function descriptions were closely linked to responses on the dependent variables. For instance, the description of soils as 'essential' very much suggest that farmers may actually know the various functions of soil other than crop production. Other descriptions of soils, such as 'organic matter', also suggest why most famers agreed that organic fertilizers are good for soils. Similarly, descriptions of soil as 'important', 'vital', 'living' and 'essential' make responses on opinions on whether soils should be protected like other natural resources less surprising. There is no doubt farmers possess good knowledge of their local soils, as various studies have suggested (Ingram *et al.* 2010; Schiermeier 2013; Rushemuka *et al.* 2014; Tesfaye 2014), the main question is how this knowledge can be translated into effective soil conservation practices for sustainable agriculture. Although

results showed a high level of awareness of the benefits of soils other than crop production, its association with age and farm ownership suggest the need to effectively engage farmers in knowledge exchange networks for the overall benefit of soil conservation. With higher awareness of the benefits of soil in older farmers and 'farm owners', a possible knowledge transfer network between farmers can involve the older farmer and 'farm owners' sharing their knowledge about soils. Farmers within these categories can also be positioned to serve the interest of farmers in the development of soil conservation policies in the UK. Other authors have reported, the need for farmers' participation in soil conservation (Sudha 2015) and sustainable agriculture (Harris *et al.* 2008) policies, particularly involving those farmers with more awareness of the benefits of soil in such activities. However, participation should go beyond stakeholder engagement as such farmers could make significant contributions to policy development.

High levels of familiarity with soil conservation were also reported in the results and, while it remains unclear whether or not farmers actually know what soil conservation entails, the association observed between it and educational level offers opportunity for soil conservation and sustainable agriculture in the UK. Since farmers were not asked to define soil conservation, it is not certain how familiar they are, however previous studies (Ingram 2008; Ingram *et al.* 2010; Kings 2014) and results from this study, especially the medium to large association with educational level, suggest that UK farmers might be indeed be familiar with soil conservation. With the expectation that the more educated farmers will be more familiar with soil conservation, highly educated farmers can play a leadership role in soil conservation networks between farmers. Opinion on whether soils should be protected like other natural resources also shared a medium to large association with education and therefore supports the role for highly educated UK farmers in soil conservation.

Although opinion on the use of organic fertilizers on soils did not share a significant association with any independent variable, it had a significant association with opinions on whether soils should be protected like other natural resources and there was an overall high support for organic fertilizer use on soils. Earlier Duruiheoma *et al.* (2015b) identified the importance of anaerobic digestion (AD) technology in promoting soil conservation and sustainable agriculture. Rich organic fertilizer called the digestate is one of the benefits of AD reported, and the support for organic fertilizer on soils here shows that informing UK farmers of the benefits of AD can promote its development, thereby supporting sustainable agricultural production.

5. CONCLUSION

Building on the principles of ethnopedology, this study has shown the perception UK farmers have of soils and how this can influence soil conservation and sustainable agriculture. The results show that UK farmers have scientific knowledge of soils, awareness of the various benefits of soils and are quite aware of soil conservation. Age, farm ownership and level of education shared significant association with some dependent variables, and these associations can be useful in efforts to promote soil conservation and sustainable agriculture in the UK. The association between opinion on the need to protect soils like other resources and support for organic matter use on soils as well as their response distribution supports the promotion of AD technology in the UK. Also, the use of Twitter for data collection in this study stresses the importance of social media in agricultural research.

This paper represents a useful tool in the development of policies and programs for soil conservation and sustainable agriculture, agricultural research in these areas within the UK, and developing message to encourage the uptake of AD among UK farmers. The methodology can effectively be applied elsewhere, considering the overwhelming presence of social media globally.

6. RECOMMENDATIONS

Based on the findings of this research, the following recommendations are made:

I. A participatory approach that will involve farmers should be considered in the development of agricultural programs on soil conservation and sustainable agriculture in the UK and elsewhere.

II. Farmer knowledge transfer networks focused on 'soil matters' can be constituted to foster soil conservation in the UK targeting older farmers and more educated farmers as key figures within such networks.

III. Social media offers opportunities for agricultural research and should be considered a viable methodological option in future. There is however need to recognise its limitations as reported in Duruiheoma *et al.* (2015a).

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