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Farmers' perception of pigeon pea fertilization and soil health indicators in Ebelle, Edo State.

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ABSTRACT

Farmers represent the largest group of natural resource managers and have a critical role to play in the agroecological transition towards sustainable land management. Such a participatory research approach involving farmers are important for the development of technologies and management innovations. The research reported aimed at eliciting farmer's knowledge on soil health within the context of fertilization and post-harvest residue management practices, as well as their awareness on the indigenous indicators of soil health in Ebelle, Edo state. Knowledge was elicited from sixty-five (65) smallholder farmers in the area through the use of questionnaires and data were analyzed using basic descriptive statistics. Results show that about 46% of the interviewed farmers used organic manure, 19.9% preferred to use chemical fertilizers while 20.2% did not adopt any method of fertilization. The use of organic manure by these farmers was attributed to its low cost (45.3%), high crop response (31.4%), availability (13.8%), and common practice (9.5%). Results also show that the majority of the farmers (72.2%) tend to burn post-harvest residue while only 6.7% incorporate these residues into the soil after harvest. Farmers in the area described eleven (11) indicators of soil health. Most frequently mentioned were; soil colour (37.3%), mesofauna (28.1%) , crop vigour (26.9%) and moisture content (7.7%). This implies that farmers have a clear notion of soil health indicators that agrees with the classical methodology of identification. However, their fertilization practices are not well established, as this can lead to degradation of soil in the area.

1.0. Introduction

The lack of sustainability of agro-systems causes environmental degradation in the form of loss of the productive capacity of the soil, reduction of biodiversity, and damage to water supply and health.

The soil resource is central to agriculture and therefore sustainable agriculture is inherently dependent on soil health. Soil health refers to the continuous capacity of soil to function as a vital living system to sustain biological productivity, promote environmental quality, and maintain plant and animal health (Pankhurst *et al.,* 1997). Proper soil management, which integrates the biological, chemical, and physical attributes, usually connote enhanced soil quality.

Farmers represent the largest group of natural resource managers on the planet and have a critical role to play in the agro-ecological transition towards sustainable land management (Edmundo *et al.,* 2015). Farmers and other land managers need to be active players in the conservation and enhancement of soil health and soil-based ecosystem services. The participatory development of soil health indicators and monitoring systems, integrating local and scientific knowledge, is proposed as a critical component of a new approach, supporting farmers to adapt to agricultural intensification and attendant land-use and environmental change. Such changes will move research on soil health towards becoming more proactive in supporting the development of sustainable land management.

Regardless of the impacts of climatic and edaphic variables on soil degradation, farmers' view and knowledge of soil is a significant production factor. In most cases, in-depth knowledge of soil processes by farmers reflects sound soil management and vice versa. Farmers' experience, local knowledge, and indigenous practices are necessary resources that should be developed in combination with scientific knowledge. Such a participatory research approach involving farmers is essential for the development of technologies and management innovations. The indicators of soil quality assessment commonly used are primarily based on scientific methodologies. However, diverse farming practices among farmers exist and such responses could be adopted into policies for future agricultural innovation development. Hence, effective collaboration among farmers, scientists, extension agents, and other stakeholders is needed to develop a practice-based adaptive soil management technique to improve soil productivity. A practical strategy is to combine indigenous sustainable land management strategies with already standard management practices.

To develop the indigenous knowledge of soil management aimed at increasing crop yield output at the community level, a starting point is to understand farmers' thoughts and perceptions of their current management methods. Thus, the objective of this research was to elicit farmers' knowledge on soil health within the context of fertilization practices and organic residue management in some farming villages in Ebelle community and to evaluate farmers' awareness of soil health indicators within the area.

2.0. Materials and Methods

2.1. Description of Study Area

This study was conducted in Ebelle, Igueben local government area of Edo state which lies between latitudes 6°30' and 7°12'N and longitudes 6°21' and 6°67'E is in the southern part of Nigeria. Within Ebelle are the villages of Ologhe, Okuta, Okpujie, Idumowu, and Eguare. The agricultural landscape of the region is dominated by paddy rice, maize, cassava, vegetable, cowpea, and pigeon pea production. Ebelle has a flat landscape, lacking in rocks and mountains. Soils in this area are predominantly utisols. Ebelle is a part of a tropical rainforest zone of Nigeria with an average rainfall of 1900mm and temperature ranges between 25°C in the rainy season and 28°C in the dry season. The rainy season in Ebelle begins in March/April and ends in October/November. Rainfalls are of high intensity and usually double maxima with a dry little spell in August usually referred to as 'August Break' (MEFRN, 2003).

Pigeon pea (*Cajanus cajan* (L.) Millsp) locally referred to as "olhene" (Esan), is cultivated by farmers in the area mostly as a legume in home gardens.

2.2. Data Collection and Analysis

A household survey was conducted to elicit knowledge from farmers who were active in the cultivation of pigeon pea. A simple random sampling method of data collection was adopted, where out of eighty (80) questionnaires distributed, sixty-five (65) were retrieved, analysed and interpreted qualitatively using basic descriptive statistics. This represents 81.2% response rate. There was a record of age, gender, education level, years of experience, farm size, household size, and other cultivated crops. Questions focused on fertilization practices, soil health indicators, and

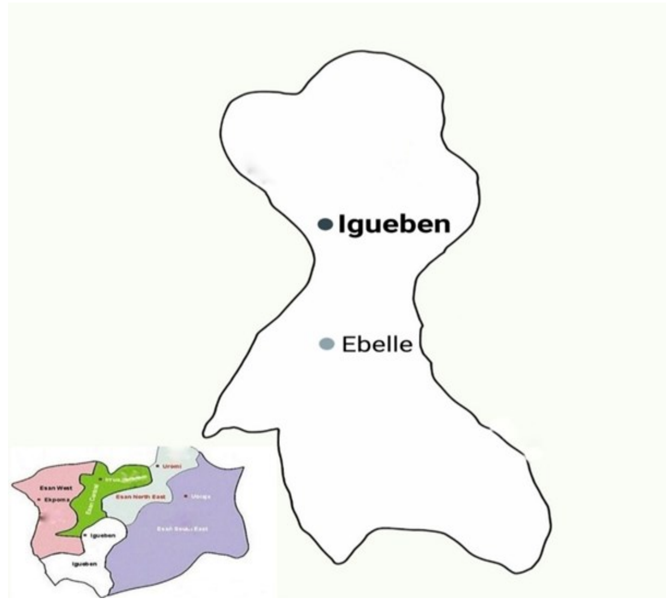

Fig 1. Map of Igueben local government showing the study area

post-harvest residue management. To understand farmers' perceptions of significant soil health indicators, seven commonly used soil indicators were selected which include; soil colour, soil structure, mesofauna, moisture content, soil texture, presence of weeds, crop residue, crop vigour, water infiltration rate, compaction and slope gradient (Doran; Parkin 1994; Paul *et al*., 2012). For each indicator, study participants were asked to indicate optimal soil conditions, using visual vignettes. Participants were also asked to rank indicators according to their perceived importance for pigeon pea production.

3.0. Results

3.1. Demographic characteristics of respondents

Table 1 shows the demographic characteristics of the respondents. The mean age (43 years) of the farmers implies that older people are more involved with little involvement of the younger generation in the cultivation of pigeon pea in the study area. There is also a dominance of female adult by 67.7% in pigeon pea farming.

39 respondents were recorded to have between 30 – 49 years of experience. Experience in farming increased the probability of uptake of adaptation to changes (Nhemachena and Hassan, 2008; Aymone, 2009; Deressa *et al.,* 2009). There was also a low level of literacy among the farmers as a majority (57.0%) of the respondents have no formal education. Knowledge of the level of literacy is, however, significantly important because a farmers' level of education is expected to influence his innovativeness and ability to make decisions on various aspects of farming. Findings also show that there is likely to be a low supply of pigeon pea in the area as only 26.0% of the farmers have farm size of >1 hectare.

3.2. *Fertilization Type Adopted by Farmers*

Fertilizers are of two major types, that is, organic fertilizer made from animal matter, human excreta or vegetable matter, and inorganic fertilizer made from synthetic mate-

Table 1. Demographic characteristics of respondents

Variables	Frequency (n=65)	Percentage (%)	Mean
Age (Years)			
16-25	8	12.3	
26-35	19	29.2	
36-45	13	20.0	40.3
46-55	16	24.6	
56-65	9	13.9	
Gender			
Male	21	32.3	
Female	44	67.7	
Educational qualification			
Primary	18	27.7	
Secondary	10	15.3	
Non-formal	37	57.0	
Years of Experience			
1-10	12	18.5	29.1
11-30	14	21.5	
30-49	39	60.0	
Farm size			
≤1ha	48	74.0	1.4
2 –5 ha	15	23.0	
6 –10 ha	2	3.0	

rials (Heinrich *et al*. 2009). The benefits of fertilization may include increasing crop yield and improving the quality of the land, improving soil texture, and faster growth of crops (EPA, 2013). However, excess application of fertilizers can do more harm than good to the crop and most importantly, the soil (Carroll; Salt, 2004). Hence, farmers' awareness of fertilization practices in the study area is of utmost importance as this has a direct effect on soil health. From the result, it perceived that farmers are averagely knowledgeable on the use of fertilization as a majority of the farmers in the area as 45.8% used organic manure (predominantly poultry dropping and farmyard manure) as their major type of fertilizer, while about 19.9% of the total respondents preferred to source for inorganic fertilizers (NPK) to improve soil health and crop quality. 20.2% of the respondents practiced both organic and inorganic and this reason was based on which fertilizer is available at the time of use.

3.3. Types of organic manure used in the area

From Fig. 4, It is shown that 46% of the farmers interviewed adopted the use of organic fertilizer. However, Fig. 2 which shows the types of organic manure in the study area indicated that three different types of manure are made readily available to the farmers (i.e. poultry dropping, farmyard manure, and fresh vegetative mulching materials). However, as shown in Fig. 5, the level of use of the other organic manures available is generally very low as farmers never make use of compost and cattle dung. Of the total respondents, 66% and 17.9% of farmers respectively, always make use of poultry manure and FYM respectively while 17.1% incorporate fresh vegetative materials into the soil. This implies that farmers in the area place more value on poultry manure and less importance on compost manure, despite its availability and this can be attributed to lack of farmers' knowledge on the importance of green manure.

3.4. Reasons for choosing organic fertilization (OF)

As shown in fig 3, of the total number of organic fertilizer users, a larger percentage (69.3%) of female farmers choose to use organic fertilizer, 38.8% perceived that the crops better responded as a result of its application, 25% however, considered it to be the cheapest form of fertilizer while the remaining 36.2% use it because it happens to be a common practice in the area. Among the male farmers (30.7%) engaged in organic farming. 72.6% embraced organic farming because of the low cost 7.4% consider it a common practice while 20.4% considered used it because of high crop response.

This implies that although a larger percentage of the respondents used organic manure, very few were aware of the benefits of organic manuring as the majority of the respondents (both male and female) adopted organic fertilization because of the low cost.

3.5. Farmers awareness on the role of pigeon pea on soil health

Among the legumes cultivated by the respondents, pigeon pea was grown on a larger scale in comparison with other legumes because of its ability to regenerate soil fertility, its low production cost, and its tolerance to pests and diseases. Farmers also explained that after cropping a piece of land to crops like maize, cassava, and yam for about three to four years, they intercropped their food crops with pigeon pea during the last cropping year of the cycle. The pigeon pea canopy was perceived to protect the soil from

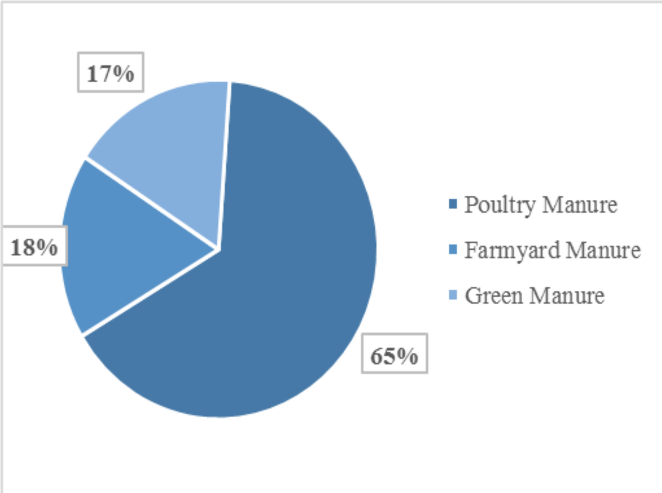

Fig. 2. Types of organic manure used by farmers

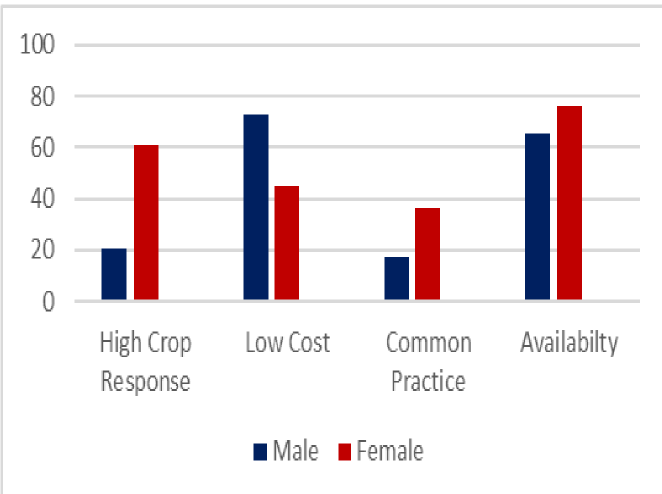

Fig 3. Reasons for choosing organic fertilization

the direct action of the sun and therefore prevent the soil from becoming hardened. According to the farmers, pigeon pea forms a canopy after one year and shades out obnoxious weeds by suppressing their growth. The farmers also explained that the leaf litter covers the soil, reduces soil erosion, prevents heating of the soil, and enhances earthworm activity. Crops are grown on the land after pigeon pea, and especially maize was perceived by the farmers to look greener, grow faster, and yield more. Rotations involving pigeon pea was often regarded by farmers as a long-term soil health management strategy. Despite its importance, only a few farmers are sensitized on its use and hence do not consider soil health when making management decisions.

3.5. Pigeon pea post-harvest residue management in the area

After harvesting the component crops, farmers allowed the land to remain under pigeon pea for 18–24 months after which the pigeon pea plants were cut down. Farmers are faced with the decision of residue management and they mostly opt for burning because it is a quick and easy way to manage the large quantities of crop residues and prepare the field for the next crop well in time. However, burning crop residue eliminates a precious opportunity to improve organic matter content and can potentially lead to a substantial nutrient loss (EPA, 2013). Fig 4 shows that only a low percentage (1.7%) of farmers use the residue as green manure and cover crop, 2.5% of the respondents burnt the dried stalks and branches as fuel in their household. Fig 4

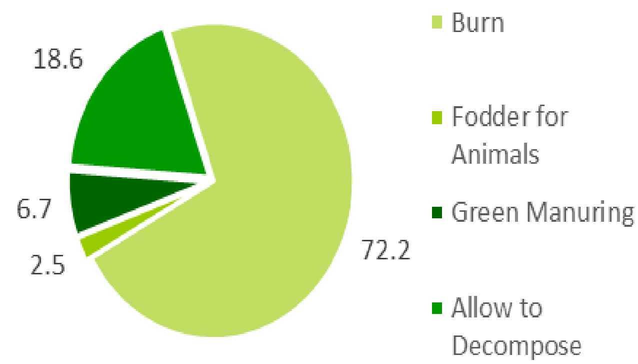

Fig 4. Farmers post-harvest residue management

also shows that 23.6% of the respondents feed the dried leaves as fodder and bedding material for their animals, while the remaining 72.2% of the total respondents including male and female, burnt the stalk on the field. This implies that the soil is not only being polluted by the burning activity carried out by the majority of the farmers but also results in loss of nutrients present in the residues and this poses a serious threat to the biodiversity in the area.

Farmers' awareness of indicators of soil health

Fig 5 illustrates indicators described by farmers to characterize the fertility status of soils on their farms. Farmers had detailed exclamatory knowledge of twelve (12) indicators of soil health with each farmer knowing an average of five (5).

The indicators were classified as physical, biological, or chemical. Farmers' assessment of soil health was qualitative and based on physical examination. 37.3% of the respondents assess soil health based on visual observation (colour) and touch while it involves passing soil through fingers, especially during ploughing, to assess the texture, moisture content, and easiness to plough. 26.9% of the interviewed farmers also used indirect methods to assess biological indicators such as crop vigour and the amount of post-harvest crop residue.

However, 12.5% focused on the presence of earthworms as the most common mesofauna. Other mesofauna mentioned include millipede, termites, and bottles. The absence of these soil mesofauna was also recognized as an important indicator of low quality and infertile soils.

Also, 4.9% of the farmers predominantly used the presence or absence of a weed or plant species as an indicator

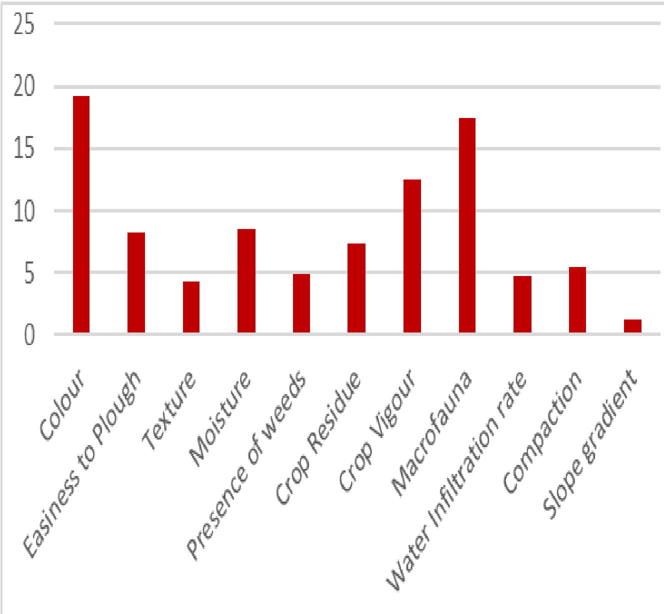

Fig 3. Reasons for choosing organic fertilization

of healthy or non-healthy soil. The use of plant species as bio-indicators in predicting certain soil properties have been documented in other preceding studies (Desbiez, 2014). For example, soils that are dominated by Pennisetum purpureum (palatable fodder), and Panicum maximum (green manure) were denoted healthy.

In contrast, 39.1% indicated no knowledge of soil health and its locally identifiable indicators. From the study, the majority of the interviewed respondents showed a good knowledge base and understanding of soil health and its effects on the productivity of crops in diverse ways as reflected in their responses.

Crop yield trend as influenced by soil health in the area

The result shows that 73.3% of the respondents observed a significant decline in crop yield in the area, 39.5% of the respondents indicated the decreasing trend was "rapid". The most frequently mentioned reasons for decreasing crop yield were low soil nutrients (40.3%), rainfall failure (12.9%) diseases/pest infestation (12.0%), and low yielding varieties (34.8%). The impacts of rainfall failure were known by farmers due to their dependence on only natural rainfall for irrigation. However, as reported by Akinbode et al., most farmers in the southern part of Edo state subjected crop yield decline to climate change, weeds incidence and pest infestation, and disease outbreak. Of the total respondents, 16.2% rather observed an increasing yield while 10.5% thought crop yield remained the same. This can be attributed to differences in management practices and the slope gradient.

Farmers observed a rapid decline in yield; they stated that continuous cultivation practices, low fertilizer application rates, and burning of crop residue were somehow the notable reasons for the decline in yield. This implies that although the majority of farmers as earlier discussed carry out organic fertilization on their field, there was still a major decline in yield. This can be attributed to management practices that are 'soil-health supporting'.

4.0. Discussion

4.1. Socio-economic factors influencing local knowledge

In this study, the gender of the respondents was found to be a differentiating factor for farmers' perceptions and management of soil health. Women in the study area were generally more

involved in day-to-day farm management activities. However, the significant differences were not tested in this study and the sample size may also have been too limited to draw stronger conclusions from obtained data.

Local knowledge is also strongly influenced by information derived from external sources (Martini et al., 2017). Farmers reported that information received on the addressed topics mainly originated from short-term government programs and other

farmers. Nevertheless, the existence of long-term frameworks and policies crop production, management practices, or availability of incentive schemes, currently remains extremely limited in Ebelle community, and there is no interference from an external non-governmental organization (NGO) in the area. As earlier mentioned, a farmers' level of education is expected to influence his innovativeness and ability to make decisions on various aspects of farming. However, the level of literacy in the area is exceptionally low. Farmers depend on residual knowledge and ideas gotten from other farmers. Relying on this as a source of information will not favour a reasonable gain in knowledge.

4.2. Knowledge on Fertilization and the Impact on Farmers' Management Decisions

Farmer fertilization practice illustrates the extent to which farmer knowledge and perceptions of ecosystem processes can influence management decisions. Despite being aware of the benefits of

organic fertilizer in terms of long-term soil health, accessibility, affordability, and efficiency, respondents appear to be unaware of the full positive effects of organic fertilizer on long-term soil fertility. Respondents in this study were thus receptive to the adoption of more "ecologically" oriented solutions where relevant, particularly if these were perceived to be causally linked to increased crop production and incomes. This finding supports the notion that farmers are unaware of long-term effects associated with farm management decisions (Van Noordwijk 2017).

4.3. Impact of Farmers' Knowledge of Soil Health

Farmer's perception of soil quality has a direct relationship to their personal experience and the local history of land use associated with specific crops and production systems that altered the landscape over time. Most farmers in the area do not know why soils have different colours and say that they are naturally the way they are, but some farmers say that dark soils are caused by the presence of organic material and nutrients. From this, we see that farmers have a clear notion of nutrient recycling used by agronomists to explain soil quality. However, the percentage of respondents that consider soil health when making management decisions is extremely low.

5.0. Conclusion

Findings revealed that farmers are equipped with some local knowledge that agrees with classical methodologies of identifying healthy soils and that most of the agricultural learning of farmers in the area comes from their own life experience. The farmers on their part are anxious to learn about the limitations of their soils and innovation which could improve productivity. They recognize and are aware that agricultural scientists possess important knowledge beyond what they know, particularly concerning the chemical composition of their land and they would like to have their soil analyzed and receive technical assistance on how to correct problems. However, the farmers are relatively poor and do not have the means to pay for private soil analysis and diagnosis and depend on government farm extension.

Based on the findings of this study, the following suggestions are made;

- Soil map of the area showing soil type, soil fertility, and other basic parameters will be necessary for future studies on sustainable soil management.
- A soil map of the area should be developed which will be necessary for future studies on sustainable soil management.
- Sensitization of farmers through training programs on organic fertilization and residues management.

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