EVALUATION OF SOIL VITAL CHEMISTRY OF SELECTED COMMUNITY FARMLANDS WITHIN AND AROUND MUBI PROVINCE, ADAMAWA STATE.

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ABSTRACT

The integration of physical, chemical, and biological properties to monitor and interpret changes in soil quality is an index that needs to be adapted at a community level for local farmers. Since the parameters needed to determine changes in soil quality may differ from one vegetation to another, routine soil test will provide a meaningful index to farmers on how to correlates whether the farmlands soil quality is improving, stagnant, or depreciating. This study was conducted to determine the health status of soils collected from farmlands within and around Mubi provinces, by measuring soil physicochemical parameters that are inherently associated with soil quality. The soil characterization was carried out by investigating the soil water holding capacity (WHC), the pH, electrical conductivity (EC), Bulk density (BD) and soil organic matter content (SOM) using conventional analytical methods. The results obtained revealed that the mean concentrations values of the physicochemical parameters in the soil samples were in the range of; 117-420% for WHC, 6.32±0.50-7.71±0.78 for pH, 0.08±0.47-0.85±0.49ds/m for EC, 1.3±0.5-1.7±0.4g/cm^3 for BD, and 0.327±0.630-1.759±0.550 % for SOM. The pH was found to vary from moderate acidic to near alkaline. The values of EC indicated that the soils are non-saline. Though, the overall results shows the soil retaining some basic health status, the low SOM recorded is an indication that in the near foreseeable future, the soil may loss it vitality. Therefore, effective soil management approaches should be implemented forthwith to salvage the soil from depreciating.

Keywords: Soil Health, Nutrient, physicochemical, Organic matter, Crops, Farmlands.

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INTRODUCTION

The dynamics of lands use for agricultural purposes are so complex, and more often influences the overall soil health status, and the key aspects of the ecosystem structures, functions, and viability (Paz-Kagan *et al*, 2014). The assessments of the ecosystem functions of soils and their importance toward food availability and sustainability underscore the importance of the management of soil resources (Kekane *et al*, 2015). Though, soil health status often falls within the ambit of water retention capacity, carbon sequestration ability, and plant productivity among other functions, it will be however, practically appreciated to relate the concept based on the capacity of the soil to function effectively in supporting and integrating the basic physical, biological, and chemical attributes of its microenvironment (Mofor *et al*, 2017; Horneck *et al*, 2011; Moebius-clur, 2016). Since the practical assessment of soil fertility requires the integrated consideration of these key soil attributes, they are however, often left as an intellectual excises only, far beyond the understanding of an ordinary farmer (Magdoff and Van, 2009)

The fertility of soil can be evaluated relative to some numeric soil standard or reference condition such as pH, bulk density, air capacity, water holding capacity, and soil organic carbon among many (Filep *et al*, 2015; Moebius-clur, 2016). However, the integration of these soil quality into a single construct were observed to be of relative value to local farmers, thus the exercise of assessing the activity levels of these important soil properties based on simple analysis can be a useful tool towards understanding the health profile of farmland soils. Though, the concept of soils' chemical, physical and even biological properties have been well accepted and integrated into soil management system; however, in our opinion, this concept should be simplified to move beyond few leading innovative producers, scientists and farmers to a broader circles, with more emphasis to a small community based farmer. Simplifying the concept could lead to a future where soil evaluation will involve a more practicable testing of soil health status for the average farmland manager.
Soil health and fertility depends largely on its physicochemical properties and despite the continued use of soil amendments such as fertilizer to improve crop productivity, soil quality in

response is experiencing a decline(Neilson *et al*, 2018). Since agriculture is the bedrock of human survival, soil health disturbances induced by Man as a results of food demands requires continues monitoring and assessment in other to forestalled possible economic crisis envisage from poor utilization and management of soil resources. Therefore, the main focus of this study is to evaluate farmlands activity in relation to soil health profile and viability of local community farmlands located within and around Mubi province. To achieve this objective, the study will be narrowed down by relating the fertility status to simple parameters such as the pH, Bulk density, moisture and water holding capacity, electrical conductivity and the organic matter content. The community in question is a typical agrarian based, thus informed the choice of this location to educate the community on the benefit of science based approaches on soil health management and fertility.

Six communities Farmland (Digil, Vimtim, Yawa, Gella, Madanya and Dirbishi) located in Mubi North and South local government, Adamawa state, Nigeria were selected for this study. Geographically, Mubi falls within the Sudan savannah vegetation zone of Nigeria, is located on latitude 10° 30'15"N and 10^0 1500" N and Longitude 13^0 1500" E and 13^0 4506" W. The area has a tropical climate with an average temperature of 32^0 to 37^0 C, with an average relative humidity ranging from 28% to 45% and an average rainfall, of about 105mm (Adebayo, 2004).

METHODS

Sample Collection and Treatment

The soil on the farm land for the total metal determination was collected from the farm land in Mubi North and South ranged from (10-20cm and 20-30 cm depth). The sampling was conducted in November of 2017, December of 2017 and January of 2018. The collection site is 100 m away from the river side and each point of collection was on different portion of farm land in the six communities of Mubi North and Mubi South of Adamawa State. Soil samples from each site was collected and homogenized using mortar and pestle and air dried overnight in circulating air in an oven at 30°- 35°C. And sieve through a 2 mm sieve.

For the physiocochemical analysis, the Electrical Conductivity (EC) of the soil was conducted using the methods described by Bower and Wilcox, 1965. The soil Bulk Density (BD) by methods described in NRCS, 2013, while standard pH meter was used for the determination of the soil pH (Barbes *et al*, 2014). The determination of the water holding capacity was conducted using the method described by Chairman and Murphy, 1998. The organic matter content of the respective soil samples were determined using Walkley and Black technique as adopted by Krishan *et al*, 2009

Statistical Analysis

The obtained results were presented as mean ± SD (standard deviation). All differences are considered significant at $p<0.05$ using Analyse-it (version 2.3).

RESULT AND DISCUSSION

When considering soil health dynamics in relation to soil pH, and organic carbon content, physical properties such as the texture, bulk density, electrical conductivity were observed to also exerts a reciprocal relationship on the potential rooting volume, penetrability of roots, moisture/or water holding capability, nutrient mobility and uptake and same time determine crop-soil compatibility(Mofor *et al*, 2017; Cherubin *et al*, 2017**;** Ghaemi *et al*, 2014). As presented in Fig. 1, the soil health status collected from the community farmlands shows the pH value for the respective six locations falling between 5.79±0.22 to 8.70±0.51. The highest pH values were recorded in the month of November in Blue house (8.70±0.51) and Dirbishi(7.85±0.31) soil samples. Though, an alkaline pH value was recorded in the month of November in Blue house soil farmlands sample, this value was observed to fall drastically to acidic range for the month of December (5.79±0.22) and January, 2018 (5.87±0.23). Blue house is a rooky area surrounded by mountains, the water draining down from the mountains containing limestone ($CaCO_3$) with little or no exchangeable H^+, leading to the formation of calcareous soils, thus, could be the possible explanation for the alkaline pH recorded for the month of November(Misra and Tyler, 1999; Wufem *et al*, 2014). Furthermore, the drop from alkalinity recorded in the month of November to the acidic rage recorded in December, 2017 and January, 2018 could be from contribution of crop residues to changes in soil pH under field conditions and more probably from the application of fertilizers (Butterly *et al*, 2013; Zhang and Marschine, 2017; Turmil *et al*,2015).

Acid-based phenomenon, initiated by the reactions of dissolved ions in soil microenvironment are largely responsible for the variation in soil pH. Ions such as aluminum (Al^{3+}), and iron (Fe^{2+} or Fe^{3+}) are acid forming species, while calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^{+}) and sodium (Na^{+}) are the predominant base forming species (McCouley *et al*,2009; Walter,2017). Soil pH, though not a growth factor indices, are widely utilized as an important indicator for nutrient availability. The availability of metal nutrient such as B, Cu, Fe, Mn, Ni, P and Zn are found between pH 5-7, while Ca, Na, Mg, and K strive in alkaline pH (McCouley *et al*,2009; Walter,2017]. Thus, from the results of the study, and based on the mean pH values of 6.32±0.5, 6.58±0.5, 6.60±2.87, 6.79±0.96 and 6.79±1.78 taking from the soil farmlands at Digil, Yawa, Madanya, Blue House and Vimtim; it could be suggested that N, P, K, S, Ca, and Mg are the major nutrient, with traceable amount of Zn, Cu, Mn and B. Based on the pH value of 5.79 and 5.87 recorded in the month of November and December in Blue House soil samples, Fe Zn, Cu, Mn and B are expected to be the predominate species. Meanwhile, neutral to near alkaline pH are recorded in the soil samples of farmlands in Dirbishi, this however suggest that base forming species such as Ca, K, Na and Mg, Mo are the dominant nutrient available (McCouley *et al*,2009; Walter,2017).

Practically, the disposition of plants for a certain pH range is often determined by their appetite and requirement for specific nutrient and not because of the pH in actual sense. Thus, defining the desirable soil pH range for optimum plant growth from one species of crop to another. However, soil pH 6.0-7.5 are most favorable to wide range of crops considering the fact that most nutrients become readily available at this pH range (Amacher *et al*, 2007). Therefore, from the pH range taking from all the locations in this study, crops such as legumes, beans, potato, rice and must vegetable plants could strive effectively(Neilson *et al*, 2018, Moebius-clur, 2009; Walter,2017)

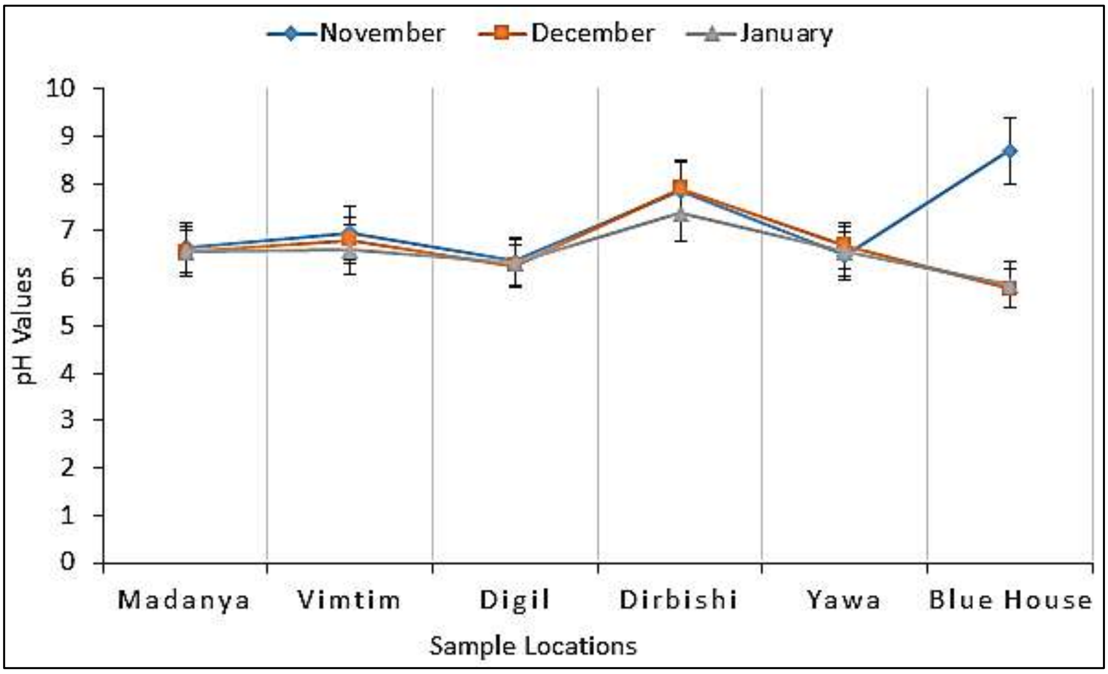

Fig. 1 showing the pH values for all the sample locations. The results are presented as Mean ± SD of three replicate analysis.

Though, EC is often used to measure the ability of a material to transmit electricity, it is also a direct reflection of the presence of dissolved substances or degree of salinity. Although EC is not a direct reflection of a specific ions or salt compounds, it has been correlated to reflect the presence of nitrates, potassium, sodium, chloride, sulfate, and ammonia and served as an effective way to determine the texture of soil particles (Wagh, *et al*,2013). From the result presented in Fig. 2, the list mean value for EC measured was in Blue House (0.08±0.47 ds/m) and the highest in Vimtim (0.85±0.49 ds/m). The reference value donating the degree of salinity suggest any soils that have EC <1 deciSiemen per meter (dS/m) are considered marginally or nonsaline. Salinity in these range does not affect most crops and soil microbial processes. However, soils that have EC >1 dS/m are considered to be saline. Important microbial processes, such as nitrogen cycling, production of nitrous gases and other N oxide gases, respiration, and decomposition of organic matter are affected at this range (Smith and Doran, 1996). Thus, from the EC result of this study, the soil samples in Digil (0.16±0.56 ds/m), Dirbishi (0.17±0.57 ds/m), Yawa (0.14±0.50 ds/m) and Blue House (0.08±0.47 ds/m) are non-saline, Madanya (0.32±1.07 ds/m), and Vimtim (0.85±0.49 ds/m) soil sample are moderately saline. The higher EC value recorded in Vimtim may suggest activity from fertilizer application. Though, the EC for these locations are considered moderate, however, continues monitoring of EC level should be encourage as some crops are sensitive and intolerant to salty environment (Maas, and Hoffman. 1977).Beans for example are considered a very highly sensitive crops, it can only be grown without yield damage in soils with EC below 2 dS/m. On the other hands, crops like Barley strive even at soil with EC of 16 dS/m (Maas, and Hoffman. 1977). Therefore, from the EC values recorded in this study, the soil samples in the respective locations could be consider suitable for wide varieties of crops, ranging from Cereals crops, rice, potatoes to wide range of vegetables (Maas, and Hoffman. 1977)

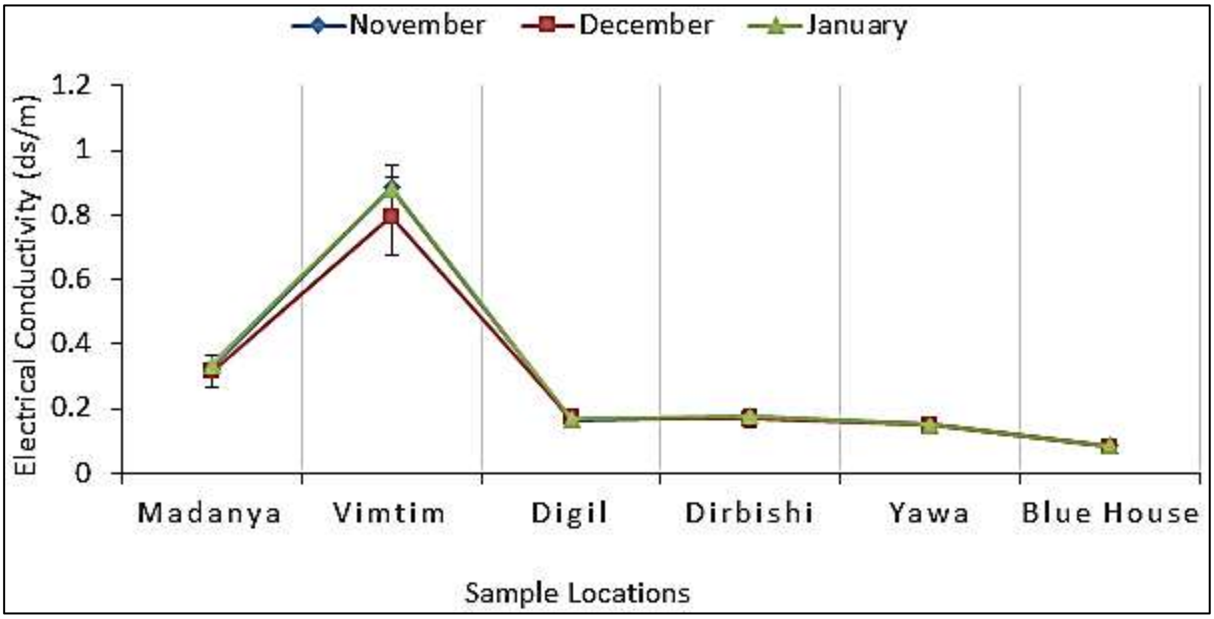

Fig. 2 showing the Electrical Conductivity (EC) values for all the sample locations. The results are presented as Mean ± SD of three replicate analysis.

Bulk density (BD) is the weight of dry soil per unit of volume typically expressed in grams/cm^3 used as an indicator to determine the level of soil health and compaction. In addition to its role in influencing plant nutrient availability, BD also influences the water holding capacity of soil, affects infiltration, rooting depth, and influences soil microorganism activity (Parra-González and Rodriguez-Valenzuela, 2017). The inherent factors that reportedly affect BD are dependent on soil organic matter, mineral composition and texture (sand, silt, and clay). This means that, BD increases with increasing and rock content and decreases with increasing organic matter content (Amacher *et al*, 2007). The results in Fig. 3 shows that the soils collected from the respective farmlands had low BD values ranging from 1.3 to 1.7g/cm^{3}with mean values of 1.4±0.4, 1.3±0.5, 1.6±0.4, 1.4±0.4, 1.7±0.4 and 1.5±0.5 g/cm^3 for Madanya, Vimtim, Digil, Dirbishi, Yawa and Blue House farmlands respectively. Research shows that roots grow well in soils with bulk densities of up to 1.4 g/m^{3}and root penetration begins to decline significantly at bulk densities above 1.7 g/cm^3(Fisher and Binkley 2000; Sutton 1991). Therefore, the BD mean values recorded in this study are within the ideal BD for plant growth (Amacher *et al*, 2007). As discussed above, we observed that some inherent factors can affect BD, and similarly, moisture content of the soil are reported to have the ability to exert some effect on BD. Air or water containing nutrient can fill up the pore space, thus an increase in moisture content means a decrease in air-filled pores (Chaudhari *et al*, 2013). Details on this inverse relationship are considered on Fig. 5.

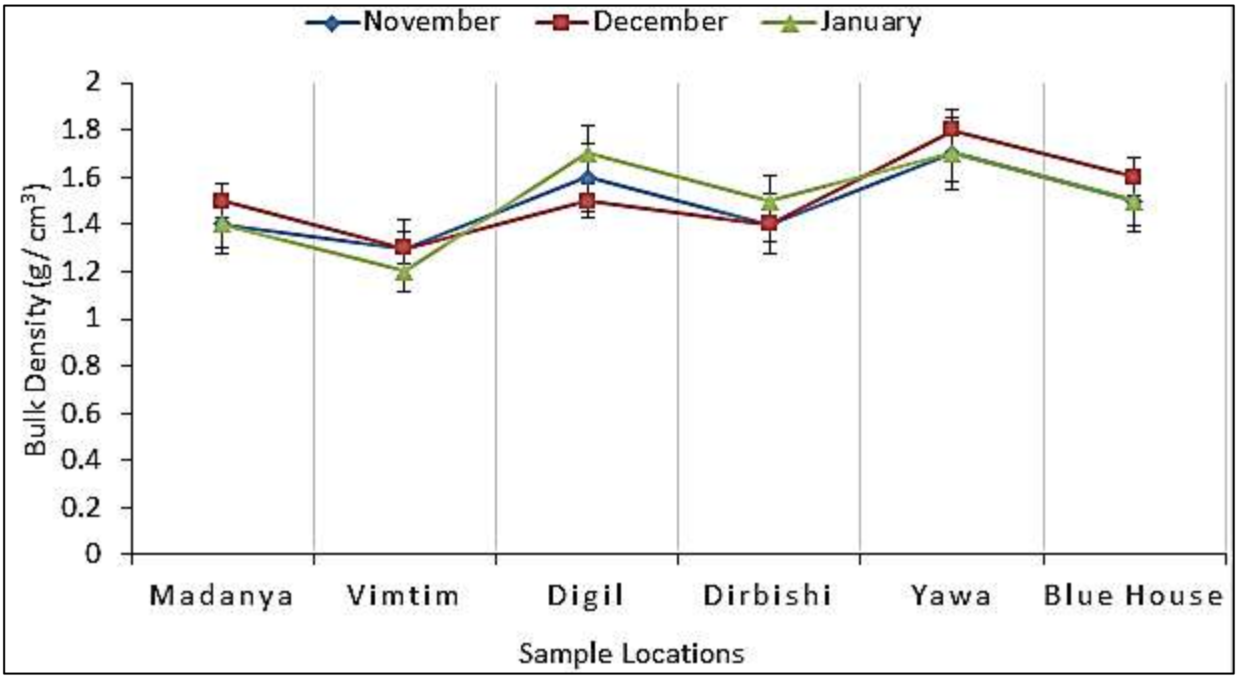

Fig. 3 showing the Bulk Density (BC) values for all the sample locations. The results are presented as Mean ± SD of three replicate analysis.

Further to our discussion on the inverse relationship between BD and soil moisture level, irrespective of the availability of pore space for root growth, a decrease in soil moisture content could lead to a decline in root growth (Borkar, 2015).The bread crumbs like structure of a healthy soil allows water to infiltrate or percolate deep into the soil, thus, acting as a giant moisture holding sponges. This morphology have a direct influence on the *nutrient* content of food crops, therefore, available water holding capacity (WHC) is the amount of soil moisture held by the soil spongy structure and made available to plants. The WHC, directly or indirectly affected by organic matter and soil compaction facilitate the solubility and mobility of soil nutrient (Borkar, 2015).
The moisture contents which is directly proportion to the percentage of WHC as presented in Fig. 4 ranges in mean values from 117±0.60 – 420±0.40. As shown in the figure, the percentage of the distribution of the WHC are independent of sampling months. However, the highest percentage mean variation are observed in soil samples collected in farmlands of Madanya; 410±0.12, 430±0.19 and 420±0.09 recorded

respectively in month of November, December and January, 2018. Blue house in the December season of 2017 have the highest value (290±0.15%) while the sample from Dirbishi during November season of 2017 have the least values of (110±0.20%). The higher moisture content in the wet season explained why plants grow healthier compared to dry seasons. Change in temperature and rainfall influence the availability of soil moisture contents and solution soil chemistry. Therefore, by changing soil solution chemistry, moisture fluctuations could regulate the availability of nutrients, and the field distribution of plant species (Misra and Tyler, 1999). The response of plant species to soil moisture is indeed guided by the available nutrient solution and mobility. Generally, plants roots and shoots grow exponentially under high moisture content than at lower moisture level. However, the response is not entirely due to the available moisture content in the soil but are observed to be influenced by the distribution of nutrient that are friendly disposed and strive under higher moisture condition (Misra and Tyler, 1999; Gines *et al* 2018). Under appropriate pH range, water soluble nutrient are readily made available under higher moisture condition. Study shows that, the concentration of K, Mg, P and Mn, in soil increases with increased in soil moisture, on the contrary, the comparatively high concentrations of Ca and Fe were observed under low moisture condition (Misra and Tyler, 1999). In this study, considering the mean pH value of 6 to 7 recorded in all the farmlands soils further supported the assumption that the soils sample may contain the following nutrient such as N, P, K, S, Ca, and Mg as major nutrient, with traceable amount of Zn, Cu, Mn and B.

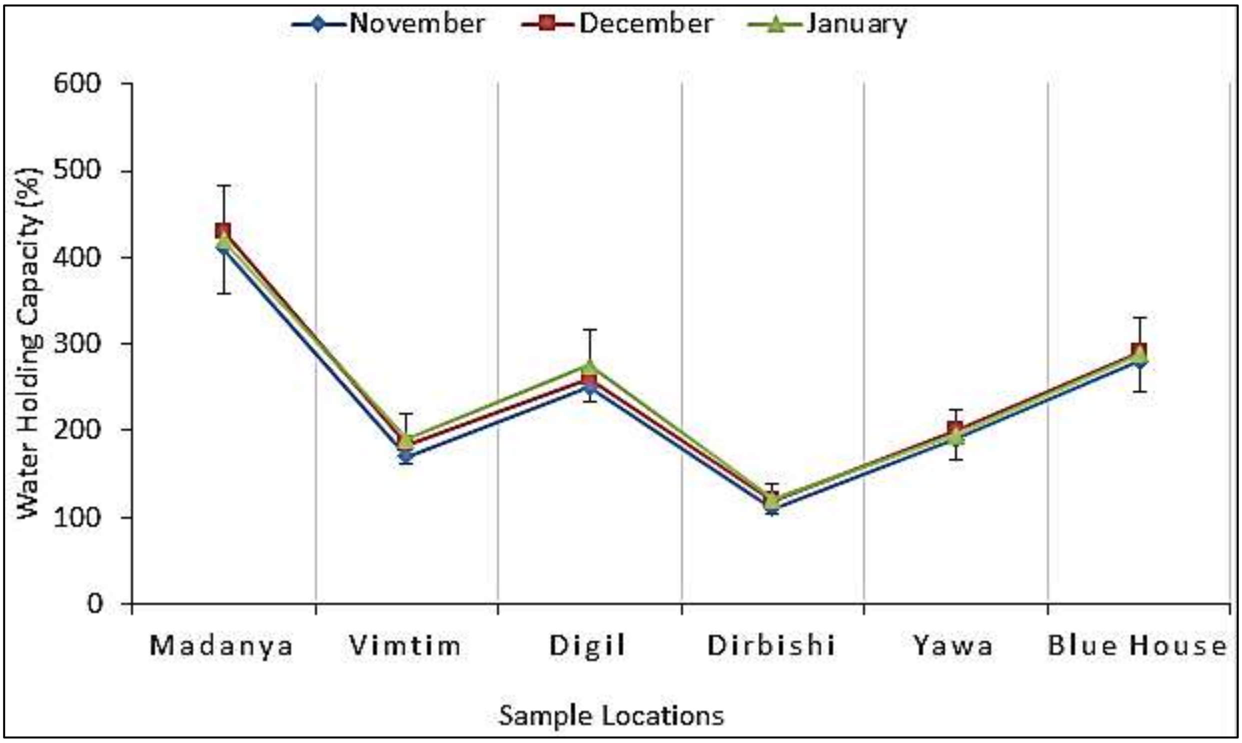

Fig. 4 showing theWater Holding Capacity(WHC) for all the sample locations. The results are presented as Mean±SD of three replicate analysis.

Among the widely recognized soil health indicators, organic matter has the overwhelming effect on soil properties. Although it is generally present in minute quantity, its effect on soil health far exceeds its percentage share of the soil volume. Though, it constitute only about 1 to 6 % of soil volume, it serve as a mitochondria for nutrients, provides a platform for cation exchange process, and regulate the release, fixation and reabsorption of nutrient(Han et al 2018). The results obtained in this present study as presented in Fig 5, revealed that, the list SOM was recorded in Madanya (0.320±0.21 %) in the month of November, 2017 and the highest content recorded at Blue House (1.759±0.16%). While in the December season of 2017 the organic matter content ranged from 0.330±0.23% at Madanya and 1.660±0.21% at Blue House. Similarly, the lowest organic matter content in the January season of 2018 was recorded at Madanya (0.330±0.19%), similarly the highest was at Blue House (1.858±0.18%). Higher organic matter contents were generally recorded in January season compared to November season. This could be due to the lower soil moisture contents during the dry season which retards the activities of the microorganism involved in the organic matter decomposition, thereby accumulating more organic matter in the dry season. The organic matter content was low as a result of intensive use of these soil and rapid mineralization of organic matter under semi rapid condition (Han et al 2018). Consequently, in addition to dwindling rainfall, typical of savannah vegetation, the residual crops that are supposedly left behind after harvesting to decompose into manure/humic substances are converted into feeds for animals thereby denying the soil from replenishing the used up organic matter; leading to a generally low biomass production (Lombin, 1983; Jones and Wild, 1976; Balasubramanian *et al*, 1984; Jone, 1973, Kowal and Kassam, 1978)

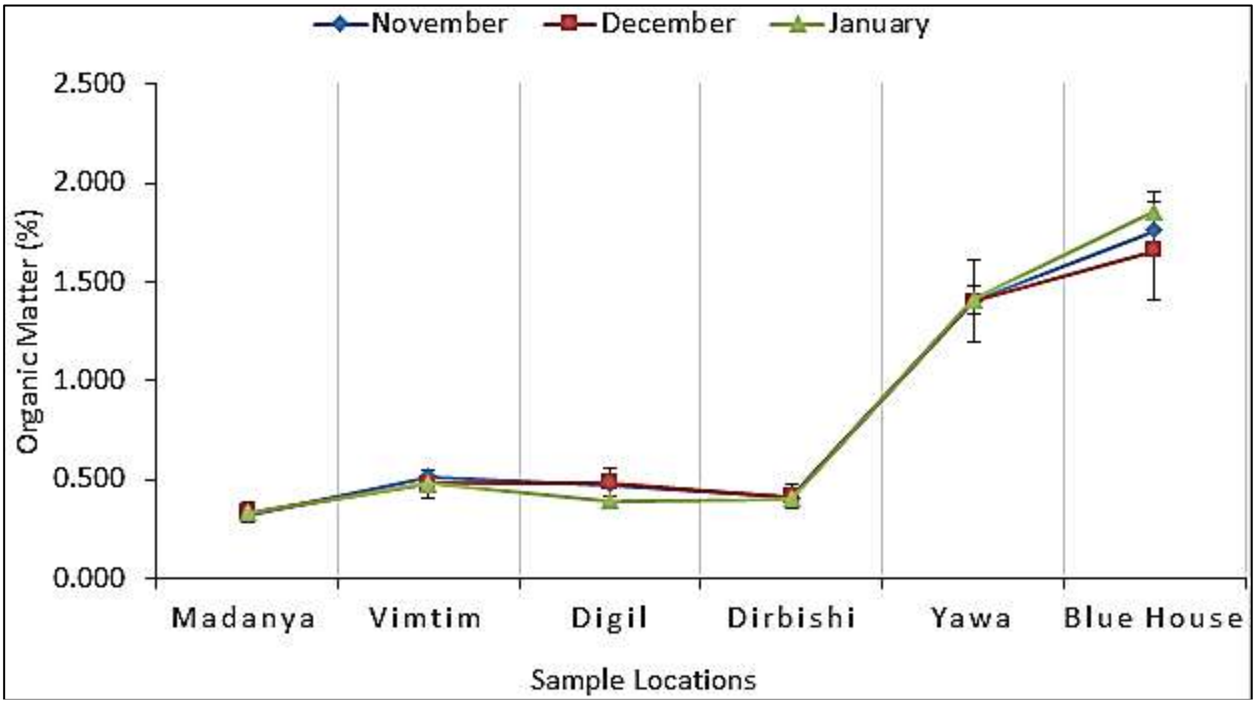

Fig. 5 showing the Organic Matter Content for all the sample locations. The results are presented as Mean ± SD of three replicate analysis.

The overall results from this study thus, suggest certain degree of life in the selected soil samples. The soil vital signs based on the results obtained suggest that at least on the shorter term, on the average, there seems to be no immediate threat from the following indicators pH, BD, EC and WHC except off course the low amount of available SOM in the selected farmlands. The decrease in the SOM content will in the foreseeable future influence some changes in the viability of other soil properties. As discussed above, SOM is like a mitochondria for nutrients, it provides a platform for cation-exchange process, and regulate the release, fixation and reabsorption of nutrient. Changes in this properties as a fall out of SOM availability in the soil is one of the factors which makes it difficult to define a critical or desirable SOM content for local farmers (Sparling *et al*, 2003). Though, a threshold values of 1 to 5.1% for SOM or 0.6 to 3% for SOC are considered an acceptable range, this proposed range according to several studies fall short of meeting the true actual soil properties from local farmers point of view (Sparling *et al.* 2003; AuneandLal 1997; Körschens *et al*, 1998; Loveland and Webb 2003). Despite the fact that the function of SOM can be replaced to a large extent following tillage, or use of mineral fertilizers, this practice indeed has some limitation especially in a situation where environmental conditions is unfavorable and crop demands heightened. This will put pressure on the lands leading to soil degradation and fertility loss (Mohammadi *et al*, 2011). Therefore to meets the nutrient supply and to replenished the used up SOM, integrated soil fertility management approach using combination of both mineral fertilizers and humic-organic inputs will augment the shortfalls as a results of loss in SOM (Richards *et al.* 2016; Vanlauwe *et al,* 2010; Zhang and Marschine, 2017; Turmil *et al*,2015)

CONCLUSION

The results indicate that the soil pH is moderately acidic and slightly alkaline. The Electrical conductivity values of the soils further suggest low salinity nature of the soil, while the bulk density provides a favorable space for rooting and water retention/holding and availability. These features were considered significant, considering their role in facilitating nutrient availability and mobility. However, the organic matter level, though at a low range indicate the need to revisit the soil management system in these communities. The soil vital signs based on the results obtained suggest that at least on the shorter term, on the average, there seems to be no immediate threat from the following indicators pH, BD, EC and WHC except off course the low amount of available SOM in the selected farmlands. The decrease in the SOM content will in the foreseeable future influence some changes in the viability of other soil properties. Suggesting the need to develop an integrated soil fertility management approach using combination of both mineral fertilizers and humic-organic in puts to salvage the soil from depreciating.

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