Effects of Tillage and Fertilizer Application on Soil Physico-Chemical Properties in Pearl Millet Field in Northern-Central Namibia

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ABSTRACT
The influence of Physico-chemical properties of soil as affected by tillage systems and fertilizer applications as it has a direct bearing on plant growth and cropping systems sustainability. The study conducted a field experiment during the 2020/2021 cropping season at the Ogongo Campus of the University of Namibia, using a split-plot design for determining the effects of different tillage systems and fertilizer applications on soil nutritional characteristics. The triangular method was applied to the settling field results to determine physical soil texture. The effects of tillage and fertilizer on different soil physical and chemical properties were tested using Parametric Analysis of Variance. The results depicted that a predominant sandy loam characteristic is possessed by the soil. Further, it was shown that tillage effects were statistically significantly different on N (p < 0.001), P (p = 0.013), K (p = 0.004). Similarly, fertilizers influenced soil N, P, and K, with respective p-values of 0.076; <0.001 and 0.044. Interaction between tillage and fertilizers has shown significant statistical differences in all three elements (Nitrogen, Phosphorus, and Potassium). The study concluded that the adoption of appropriate fertilizer management combined with suitable tillage practice can enhance soil fertility and improve crop production since soil physicochemical properties are influenced by soil tillage and fertilizer practices.

Keywords: Soil, Physico-chemical, Tillage, Fertilizer, Pearl Millet

I. INTRODUCTION

Soil form a thin layer of Earth’s crust that provides a natural medium to the plants for growing. It is made up of chemical, physical, and biological characteristics (Gu, Zhang, Tu, & Lindström, 2009). In Namibia, the average millet yield for the period 2002-2011 was 250 kg ha⁻¹ which was three times lower than the 2014 world average of 900 kg ha⁻¹ (FAO, 2017). Soil physical properties play an important role in regulating the growth and yield of crops; therefore, it is considered as a key element of agriculture.

A potential medium is provided by the soil to all kinds of crops and plants for their growth and development (Anderson, 1997). The base for all the production systems in forestry, agriculture, and fishery is provided by soil. Water and nutrients are stored in the soil so that they are available for the crops, vegetation, grazing lands, and forest when they need it. The most important physical characteristics of soil that support the growth and development of plants to render economic benefits include (Levine, 1998) Soil texture – the relative proportion of sand, clay, and silt. Soil color – indicates the status of soil. Soil structure – arrangement of aggregated soil particles. Soil water – to provide moisture to the soil.

Soil is In addition to that testing the soil is well-known as a scientific tool used for assessing the inherent power of soil in supplying plant nutrients (Shen, et al., 2004). Scientific research and extensive field demonstrations have established the benefits of soil testing, based on the actual properties. The soil is tested by the farmers based on the volume of soil need by the plants and the supply of the required resources (Liu, et al., 2010). The relationship between soil properties and soil management strategies can be explained by soil testing. Sustainable world production required good soil management in agriculture land. In developing and developed countries this is where you find farmers with an effort to achieve sustainable soil management.

In Northern-Central Namibia, the yield of the staple food crop pearl millet is usually low, causing food insecurity. This region is characterized by infertile sandy soils and low rainfall. The properties of soil are affected by soil management that in turn affects the growth and development of plants. The Physico-chemical properties help in determining the way of using it either for agricultural purposes or non-agricultural purposes. The size, arrangement, proportion, and mineral composition of the soil particles affect the properties viz, nutrient-supplying ability, water holding capacity, aeration, infiltration rate, permeability, and plasticity of the soil. Currently, there is little information on the Physico-chemical properties of local soils. Therefore, the present study aims to analyze the effects of different soil tillage and fertilization to generate information for improved pearl millet production with a specific objective of

i. Assessment of the effects of tillage and fertilization practices on soil texture,

ii. Determining the effect of tillage and fertilization practices on soil pH, NPK, organic matters, and electric conductivity.
II. MATERIALS AND METHODS

2.1 Study Site
The study took place at the Ogongo Campus farm area, which is located in the Omusati Region in the famous Cuvelai-Etoshia Basin of northern-central of Namibia. The site at which the study was conducted is mind way between Oshikuku and Outapi Township along the C46 highway and roughly 50 km from Oshakati and approximately 800 km from the city of Windhoek.

2.2 Experimental design and treatments
A split-plot design was employed to assess the synergies of soil tillage and fertilization on the growth and yield of pearl millet. Treatments consisted of comprised two tillage systems: ridge-furrow and conventional/flat-bed tillage (CT) as main plots and four fertilizer applications: cattle manure (10 t ha⁻¹), NPK mineral fertilizer (30–45–30 kg ha⁻¹ of N–P₂O₅–K₂O, respectively), combined fertilizer (manure + NPK) and a control (without fertilizer) as subplots. The experiment area was 4290.4 m² (62 m long×69.2 m wide).

2.3 Experimental management
A total of 36 samples were collected, randomly from three different spots. It is known that the field pattern bias can be minimized through the transact sampling method to render an organized sampling scheme representing the entire field (The International Plant Nutrition Institution, 2013). All the soil samples were collected within each sampling point in each tillage method for each soil depth (0 – 30 cm) that were later pooled together and one representative subsample was taken after homogenization.

### Table 1: Effect of tillage on soil texture

<table>
<thead>
<tr>
<th>Tillage</th>
<th>Sand (%)</th>
<th>Clay (%)</th>
<th>Silt (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flatbed</td>
<td>63.9</td>
<td>25.4</td>
<td>9.4</td>
</tr>
<tr>
<td>Furrow</td>
<td>65.8</td>
<td>24.4</td>
<td>10.0</td>
</tr>
<tr>
<td>Ridge</td>
<td>66.7</td>
<td>25.8</td>
<td>6.4</td>
</tr>
</tbody>
</table>

In Error! Reference source not found., we are presenting the soil biological and biochemical properties affected by long term fertilizers. These results revealed that the highest total nitrogen was produced in ridge tillage and the lowest in-furrow. Furthermore, the available phosphorous was noticeable in flatbed tillage. The lowest available potassium was produced in ridge tillage; while, the highest available potassium was produced in-furrow tillage. However, the result shows that tillage did not have any effect in both OC and EC.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Total N (mg kg⁻¹)</th>
<th>Available P (mg kg⁻¹)</th>
<th>AK (mg kg⁻¹)</th>
<th>OC (mg kg⁻¹)</th>
<th>EC (dS/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flatbed</td>
<td>0.839ab</td>
<td>23.72b</td>
<td>324.29b</td>
<td>2.78a</td>
<td>0.712a</td>
</tr>
<tr>
<td>Furrow</td>
<td>0.768b</td>
<td>32.52a</td>
<td>450.80a</td>
<td>2.33a</td>
<td>0.714a</td>
</tr>
</tbody>
</table>

III. RESULTS

Error! Reference source not found. shows the effect of tillage on soil structure in which mean particle size distribution was 66.7% sand highest in a ridge tillage 25.8% clay was highest in ridge tillage and 10.0% silt highest in-furrow tillage .the particles size distribution within 0-30 soil depth.

In Error! Reference source not found., we are presenting the soil biological and biochemical properties affected by long term fertilizers. These results revealed that the highest total nitrogen was produced in ridge tillage and the lowest in-furrow. Furthermore, the available phosphorous was noticeable in flatbed tillage. The lowest available potassium was produced in ridge tillage; while, the highest available potassium was produced in-furrow tillage. However, the result shows that tillage did not have any effect in both OC and EC.

Fertilization application did not affect total nitrogen, AK, and OC, however, the result shows a great effect on available phosphorous and electrical conductivity.

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Table 3: Effect of interaction of tillage and fertilizer on chemical properties

<table>
<thead>
<tr>
<th>Tillage × Fertilizer</th>
<th>Total N (mg kg⁻¹)</th>
<th>AP (mg kg⁻¹)</th>
<th>AK (mg kg⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flatbed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>0.77ab</td>
<td>7.79e</td>
<td>389bc</td>
</tr>
<tr>
<td>Manure</td>
<td>0.87ab</td>
<td>11.04de</td>
<td>286c</td>
</tr>
<tr>
<td>Inorganic</td>
<td>0.82ab</td>
<td>48.96ab</td>
<td>369.7c</td>
</tr>
<tr>
<td>Combined</td>
<td>0.897ab</td>
<td>27.09cd</td>
<td>252.5c</td>
</tr>
<tr>
<td>Furrow</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>0.91ab</td>
<td>7.68e</td>
<td>337c</td>
</tr>
<tr>
<td>Manure</td>
<td>0.98a</td>
<td>14.24de</td>
<td>598.7ab</td>
</tr>
<tr>
<td>Inorganic</td>
<td>0.517b</td>
<td>51.68ab</td>
<td>265.0c</td>
</tr>
<tr>
<td>Combined</td>
<td>0.664ab</td>
<td>56.48a</td>
<td>602.5a</td>
</tr>
<tr>
<td>Ridge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>0.934a</td>
<td>15.36de</td>
<td>280.0c</td>
</tr>
<tr>
<td>Manure</td>
<td>0.837ab</td>
<td>7.84e</td>
<td>218.3c</td>
</tr>
<tr>
<td>Inorganic</td>
<td>1.007a</td>
<td>35.84 bc</td>
<td>338.3c</td>
</tr>
<tr>
<td>Combined</td>
<td>1.017a</td>
<td>39.84abc</td>
<td>307.5c</td>
</tr>
</tbody>
</table>

Means followed by the same letters in Column are not significantly different p<0.05 by Turkey (HSD ) at 5% levels.

IV. DISCUSSION

The results showed that soil texture was not influenced by both tillage and fertilizer treatments and that it was predominantly sandy loam (Error! Reference source not found.). These results are expected because most soils in North-Central Namibia are characterized by sandy or sandy loam soils. It is not possible to change the soil texture by tillage human activity, fertilization may alter soil texture but this may take many years to occur because it is a permanent soil feature (Habtegebrial, Singh, & Haile, 2007). The sandy characteristic of soils provides them with poor nutrients retention and high drainage abilities. Therefore, proper soil fertility management strategy is required by the textural class of the pear millet field soil to optimize rice yields. It is also important to understand the proportions of different-sized particles in soils to be aware of the soil behavior and their management (Bertha, 2012).
The results revealed that the highest OC was produced in manure fertilizers and flatbed tillage, this is because flatbed tillage is conservation tillage and it can conserve organic matters, manure fertilizer is a natural source of organic matter that takes long to decompose this corresponds with the results found by Bertha(2012).

The results indicated that the amount of EC within all the treatments was almost similar, meaning there was no direct effect from both treatments (tillage and fertilizers). The soil electrical conductivity falls within the reported soil saline levels, characteristically based on the standard reference values for interpreting soil properties (Hamza, Al-Adawi, & Al-Hinai, 2011). Several factors result in soil salinity; such as low rainfall and the use of irrigation water with high levels of salt.

The results also indicated that total nitrogen was highest in ridge tillage, phosphorus and potassium were highest in furrow tillage plots. These results correspond with those of Abagandura, Eld-Deen, Nasr & Moumen (2017). Fertilizer application did not affect nitrogen and potassium, but phosphorus was highest in plots with manure fertilizers, which correspond with the results of Guzha (2002). Indication of higher total N was shown in ridge tillage and combined fertilizer, available potassium was highest in furrow tillage, and combined fertilizer, similarly available potassium as highest in furrow tillage and combined fertilizer. These results are contradicting the results by Habtegebrial, Singh & Haile (2007), who found the highest NPK levels in flatbed plots fertilized NPK chemical fertilizer, possibly because flatbed can minimize leaching and soil erosion, inorganic fertilizers are fertilizers were nutrients are readily available to the soil and plants.

V. CONCLUSION

The study results concluded that soil possesses moderate acidity, low level of soil fertility, and sandy loam textural class, characteristically. Moreover, they also possess low levels of organic carbon content and NPK content. There is an increased chance of leaching of soil nutrients as the result of soil’s electrical conductivity within low saline soil levels. Additionally, the presence of poor nutrient holding capacity corresponds to moderate to a strong negative correlation between the sand particles of soil and the nutrient elements present in the soil.

RECOMMENDATION

Soil Physico-chemical properties are influenced by tillage and fertilizer practices, the adoption of appropriate fertilization management in conjunction with suitable practice can improve crop production and enhance soil fertility. Further replication of the study needs to be done to determine the optimum tillage and fertilizer combination to improved crop production.

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REFERENCES


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