

## Effect of different type of soil as growing media on physiological quality of harvested okra (*Abelmoschus esculentus*)

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### Abstract

Soil properties are very important to be well understood before planting any crop. Different types of soil will possess different properties. The properties of soil will influence the yield and quality of crops. For instance, poor soil properties will produce low quality of okra, thus reducing consumer demand. It is necessary to find conditions that are suitable for soil in order to get the best okra quality to fulfil the demand of consumers. The purpose of this research is to determine the physiological quality of harvested okra on different types of soil which are peat soil (T1), mineral soil (T2) and alluvium soil (T3). Each treatment was replicated five times and was applied with the same amount of fertilizer (NPK 12: 12: 17: 2); 10 g. Parameters in term of quality of physical appearances were taken once after the fruits were harvested. The parameters taken include the length of fruit (cm), the diameter of fruit (mm), the colour of fruits and fruit tenderness. Parameters for growth performance were also taken for each treatment. The result obtained shows a high significant difference in term of physical features of okra such as length of fruit (cm), the diameter of fruit (mm) and fruit tenderness for each treatment. Harvested alluvium soil-based okra was found to be the most promising for fruit yield, physical quality and quantitative characteristics. This is because the result of parameters of alluvium soil (T3) is higher than peat soil and mineral soil in term of length of fruits; 17.18 cm, diameter of fruit; 19.42, yield produced; 9.8 and tenderness; 9.2. The T3 soil also has rich in micronutrients especially potassium. In conclusion, properties of soil whether chemically or physically will influence the yield and quality of crops either directly or indirectly.

## 1. Introduction

*Abelmoschus* L. or commonly known as okra are popularly known as bhindi, lady's finger, gumbo, ochro or bamia especially in English speaking countries (Khandaker *et al.*, 2017). Okra is a cash crop that is grown throughout the world. Okra is grown most of the states in Malaysia.

Okra is an important crop that is massively used by consumers and is a crucial part in daily dietary as it provides minerals, vitamins, calories and amino acid that can be found its seeds (Thompson, 1949; Schipper, 2000; Olaniyi *et al.*, 2010). It can be prepared in numerous aspects such as cooking and as medicinal uses.

Other factors that influence the quality of crop production is soil. Okras are normally planted on peat soil, mineral soil and alluvium soil in Malaysia. Mineral soil is composed of organic materials, it provides good aeration due to the various components that are present

in the soil (Schaetzl and Thompson, 2015). Concurrently, peat soils are also known as organic soils as they are normally wet with a very high-water table close to the surface of the soil and are made up of mainly rotting plant materials. Alluvial soil has the highest productivity rate with respect to other soils as it has very soft strata with the lowest proportion of nitrogen and humus but with an adequate amount of phosphate. All these soil types are very important as a planting medium because it houses root development and ensures good plant growth. Thus, this research is focused on the determination of the types of soils that is suitable as a medium for okra planting to produce high-quality okra fruit.

## 2. Materials and methods

### 2.1 Location of study

The research was conducted in the greenhouse of UiTM Melaka Campus Jasin. The okra variety of Green Torpedo was used for this study.

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## 2.2 Soil sampling and preparation

In order to characterize the soil used for the research, samples were taken across the field to a depth of 0-15 cm with the use of soil auger in Uitm Campus Jasin (mineral soil), peat soil (Merlimau, Melaka) and alluvium soil (Jasin, Melaka). Soil samples were bulked together in polythene bags, air-dried and sieved with a 2 mm sieve for routine analysis. Ph and CEC readings were determined.

## 2.3 Experimental procedures

The research comprised of field experiments. The field was arranged in completely randomized design (CRD) of three treatments with five replicates. The three treatments included T1 (peat soil), T2 (mineral soil) and T3 (alluvium soil). For positive control, NPK Blue (12: 12: 17: 2) was applied at 10 g per plant. This control was set up by the recommendation from Jabatan Pertanian. The application of fertilizer was done in 2-week intervals. Fruit development characteristics included fruit length, fruit diameter and fresh fruit weight that were recorded after harvesting using a 30 cm ruler, a digital Vernier calliper and a sensitive balance, respectively. Fruits were harvested after 45 days of planting.

### 2.3.1 Fruit fresh weight

The fruits were weighed individually from each treatment. The fruit weight was expressed as mean weight (g) using a measuring scale.

### 2.3.2 Fruit length and diameter

The length was measured as the distance from the base to the tip end of the pod from the fruit cap scar. The fruit diameter (mm) in the peduncle insertion region was measured using the Vernier calliper standard graduated scale.

### 2.3.3 Fruit surface colour

This attribute had been identified using the RHS Colour Chart. The colours of the fruits were matched by holding the sample directly behind the colour sheets separating the closest matching colour chip.

### 2.3.4 Tenderness of fruit

The characteristics were measured organoleptically by a panel of 3 members with a scale from 1 to 10, where 1 indicates very hard and 10 indicate very tender fruits.

### 2.3.5 Plant height

Plant height (from soil-based to the highest shoot) was measured on a weekly basis using a ruler in cm.

## 2.3.6 Number of fruits

Data were taken manually for number of fruits observed. The number of new buds and the number of harvested okras were counted.

## 2.4 Plant nutrient analysis.

For sample preparation, fruits were cut into small pieces and dried at 60°C for a period of one to three days or 24 to 72 hrs. For the analysis of the sample, samples were ground and ash at 300°C for an hour, the temperature was then increased to 550°C for the next 6 to 7 hours. A few drops of distilled water and 2 mL of concentrated HCl was added to moisten the sample and being left to evaporate on a hot plate. A volume of 10 mL of 20% nitric acid (HNO<sub>3</sub>) solution was used to digest the nutrients content of the fruits by using ICP after the solution was being filtered.

## 2.5 Statistical analysis

Data were subjected to analysis of variance (ANOVA) and means were compared by Tukey test ( $p < 0.05$ ) using SPSS software.

## 3. Results and discussion

### 3.1 pH reading

Based on Figure 1, the value of the pH indicator for each soil treatment shows that T1 has the highest mean value which is 5.6768 for pH value index. This is followed by T2 which has a mean value for pH index of 5.4833 and T3 which indicated the lowest mean value at 5.35 for pH value index. The significant difference between T1, T2, T3, the significant value had been compared with P-value where P is less than 0.05. Thus, it shows that the significant value is smaller than the P-value. Hence, there is a significant difference between each treatment. Many factors contribute to soil acidity, one of the main factors is climate. Rainfall contains acid-forming contaminants due to carbonic acid that forms when CO<sub>2</sub> in the atmosphere dissolves in water. The addition of Ca-forming materials to the soil will increase its acidification. Besides that, leaching can also lead to soil acidity through the transport of water below the root zone that leaches base cations such as Ca<sup>2+</sup>, Mg<sup>2+</sup> and K<sup>+</sup> from the soil and leaving acidic elements, H<sup>+</sup> and Al<sup>3+</sup> in the soil (McCauley *et al.*, 2017). Prolonged wet season will increase the leaching of Ca<sup>2+</sup> and therefore would result in soil acidification (Singh *et al.*, 2011). Bolan and Hedley (2003) stated that acidifying fertilizers and growth of legumes are the major contributions of the reduction of soil pH. For example, application of ammonium-based fertilizers and S elemental fertilizers will increase the soil acidity especially when nitrogen

leaches and is not taken up by the plants (Goulding, 2016). T3 which is alluvium soil has lower pH compared to other treatments due to application of fertilizer in rice cultivation. Stangel and De Dutta (1985) stated that rice crops in Asia used approximately 60% of N fertilizer to produce more than 90% of rice crops production.

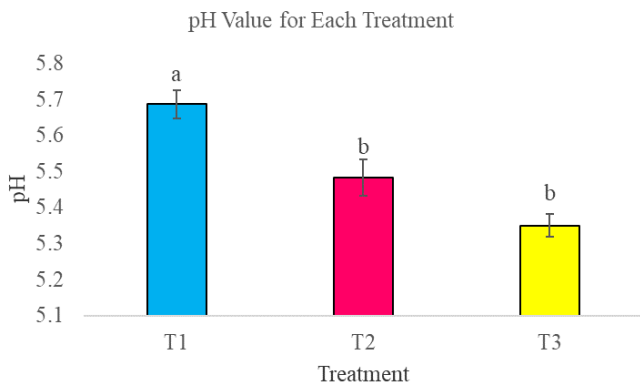


Figure 1. Value of pH indicator for each soil treatment. Different letters above the bars are significantly different.

### 3.2 Extractable Phosphorus

Based on Table 1, alluvium soil, T3 has the highest mean value which is 85.48 mg/kg in extractable phosphorus value. This was followed by mineral soil, T2 which is 18.93 mg/kg and peat soil, T1 which has the lowest mean value of 14.07 mg/kg in extractable phosphorus value. This can be shown that T3, alluvium soil has the highest phosphorus content due to flooding. Choundry *et al.* (2007) stated that there is a higher presence of P in wetland soils due to flooding and this contradicts in Ultisols, Oxisols, Vertisols, Inceptisols andisols and acid sulfate soils (Diamond, 1985). As for T2, mineral soil, its pH values that is below 5.5 and between 7.5 to 8.5 limit P availability in plants due to fixation that occurs by aluminium, iron and calcium (USSDA-NRC, 2015). T1 which is peat soil has the lowest P content because peat soil consists of low clay content and lack of Al and Fe compounds to form relatively insoluble phosphate compound that stimulates high loss of P (Ahmed *et al.*, 2006).

### 3.3 Available micronutrient

Based on Table 1, T1 has the highest value of Mn index which is 12.72 mg/kg followed by T3; 8.93 mg/kg and lastly T2 which is 7.53 mg/kg. Long-term and heavy dose applications of wastewater sludge or other organic modifications to agricultural soils and anaerobic soil conditions or poor drainage can also lead to an increase

in the Mn content (Paschke *et al.*, 2005). However, Azahar *et al.* (2011) stated that Malaysian peatland is the product of a dense mass of woody materials, usually water-logged in its natural state, shrinkage and subsidence upon drainage, irreversible drying if excessively drained, extreme acidity and low fertility status. Its structure ranges from more or less decomposed plant remains to a fine amorphous, colloidal mass. The peat medium is a structureless material that has very low bulk density, is low in nutrients and low in pH level. For Fe index, T3 showed highest Fe content which is 293.5 mg/kg. T1 recorded the lowest Cu index compared to other treatment which is 0.177 mg/kg. Peat soil composed by humus and have a high amount of organic matter tend to have Cu deficiency. Zinc deficiency is also often caused by soil liming by increasing zinc sorption (Alloway, 2008).

### 3.4 Exchangeable potassium, magnesium and calcium

From Table 1, T1 has the highest mean value at 33.69 mg/kg for K content index. This followed by T2 at 25.12 mg/kg and T3 at 20.92 mg/kg for K content index. T1 was collected from peatland on an oil palm plantation. To produce high oil yield, oil palm requires a high quantity of fertilizers such as nitrogen (N) and potassium (K). From Table 1, for all treatments, Ca cation have the highest reading value compared with others. For Ca, T3 has the highest mean value at 75.51 mg/kg and followed by T2 mean value for Ca content index at 48.37 mg/kg. Meanwhile, T1 had the lowest mean value for Ca at 34.02 mg/kg. Previous cultivation crops may influence Ca content due to application of liming at the site of all the treatments.

### 3.5 Cation exchange capacity and base saturation

Cation exchange capacity is a measure of the soil's ability to retain positively charged ions. CEC had a very important function in influencing soil structure stability, nutrient availability, soil pH and the soil's reaction to fertilizers and other ameliorants (Hazleton and Murphy, 2007).

Based on Table 2, treatment T3 has the highest mean value for CEC index at 5.8 (cmol<sub>0</sub>/kg) and followed by T2 at 3.74 (cmol<sub>0</sub>/kg). T1 had the lowest mean value for CEC index at 3.481 (cmol<sub>0</sub>/kg). Some factors influence CEC content in soil and one of these is the soil pH. Among the treatments applied, treatment T3 had lower soil pH that increases in the acidity of the soil.

Table 1. Mean value of P, K, Ca, Mg and available micronutrients for three different types of soil-based

| Soil based | P (mg/kg) | K (mg/kg) | Ca (mg/kg) | Mg (mg/kg) | Mn (mg/kg) | Fe (mg/kg) | Cu (mg/kg) | Zn (mg/kg) |
|------------|-----------|-----------|------------|------------|------------|------------|------------|------------|
| T1         | 14.07 (a) | 33.69 (a) | 34.02 (c)  | 11.02 (b)  | 12.72 (a)  | 21.29 (c)  | 0.177 (c)  | 0.99 (c)   |
| T2         | 18.93 (a) | 25.12 (b) | 48.37 (b)  | 8.17 (c)   | 7.528 (b)  | 87.33 (b)  | 0.309 (b)  | 1.314 (b)  |
| T3         | 85.48 (a) | 20.92 (c) | 75.51 (a)  | 17.80 (a)  | 8.934 (c)  | 293.5 (a)  | 0.34 (a)   | 3.443 (a)  |

Mackenzie *et al.* (2014) stated that soil that has high acidity tend to produce higher CEC value due to replacement of base cations with  $H^+$ ,  $Al^{3+}$  and  $Mn^{2+}$ . As for T2, higher Ca content compared to T1 may due to liming application. As the pH is being increased, the hydrogen held by the organic colloids and silicate clays become ionized and are replaced. The net result is an increase in the negative charge on the colloid and increases in CEC. Generally, peat soil as is T1 has a very high CEC since it has high organic matter content (Tie and Lim, 1991). However, CEC may reduce due to rise of ash content (Tie and Lim, 1991). According to Tie and Kush (1979), a waterlogged condition in peatland causes an increase in ash content value.

Table 2. Mean value of CEC for three types of soil based.

| Soil based | CEC (cmol <sub>0</sub> /kg) |
|------------|-----------------------------|
| T1         | 3.481                       |
| T2         | 3.74                        |
| T3         | 5.8                         |

### 3.6 Available micronutrient

Based on Table 1, treatment T1 has the highest value of Mn index at 12.72 mg/kg followed by T3 at 8.934 mg/kg and lastly T2 at 7.528 mg/kg. For Fe index, T3 showed highest Fe content at 293.5 mg/kg. T1 recorded the lowest Cu index compared to other treatment at 0.177 mg/kg. Peat soil composed by humus and have a high amount of organic matter tend to have Cu deficiency.

### 3.7 Plant analysis (in fruit)

From Figure 2, treatment T3 has the highest mean value at 5512.8 mg/kg for K content index. this followed by T1 at 5055.6 mg/kg. Treatment T2 has the lowest mean value for K index content at 2549.8 mg/kg. Adequate potassium nutrition is associated with increased fruit production, improved fruit colour and fruit shelf life (Kanai *et al.*, 2007). As for Ca, treatment T2 has the highest mean value which is 1542.2 mg/kg for Ca content index, and this is followed by T3 which is 1054.4 mg/kg. While T1 showed the lowest mean value for Ca content index at 718.5 mg/kg. According to Sams (1999), Ca is involved directly in reinforcing the cell wall of the plant. For Mg content, T2 has the highest mean value at 946.66 mg/kg for Mg content index. This is followed by T3 at 834.56 mg/kg and T1 has the lowest mean value for Mg index content at 742.98 mg/kg. The Increasing supply of Mg on Mg-deficient sites can help to increase the quality of farm crops. As for Fe, treatment T3 has the highest mean value which is 159.04 mg/kg and this followed by treatment T1 which is 148.46 mg/kg. While treatment T2 showed the lowest mean value for Fe content index which is 46.72 mg/kg. Fe deficiency caused significant declines in fresh fruit weight per plant and number of fruits per plant (Alvarez-Fernandez *et al.*,

2003).

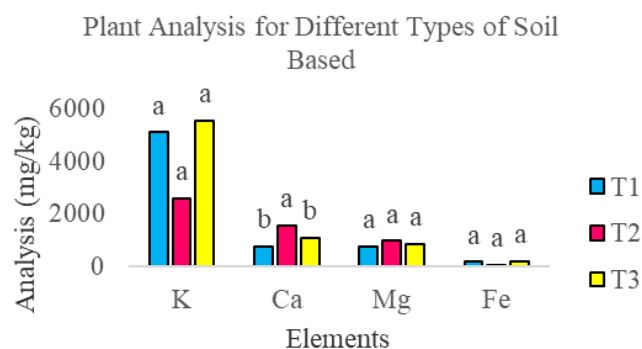


Figure 2. Plant analysis for different types of soils based (in fruit). Different letters above the bar of the same element are significantly different.

### 3.8 Plant Height

Based on Figure 3, the treatment T3 had the highest in term of plant height compared to other treatments may be due to the high availability of Fe. Iron is necessary for plant growth and development and is required as a cofactor for proteins involved in numbers of important metabolic processes including respiration and photosynthesis (Morgan and Connolly, 2013). On the other hand, treatment T1 showed the lowest in term of plant height due to P deficiency that causes the plant to have stunted growth (Hajdu, 2019). However, this result in plant height can explain the importance of nutrient content in the growth of plants. The higher dose of N might enhance cell division and formation of more tissues resulting in luxuriant vegetative growth and thereby increases plant height (Firoz, 2009).

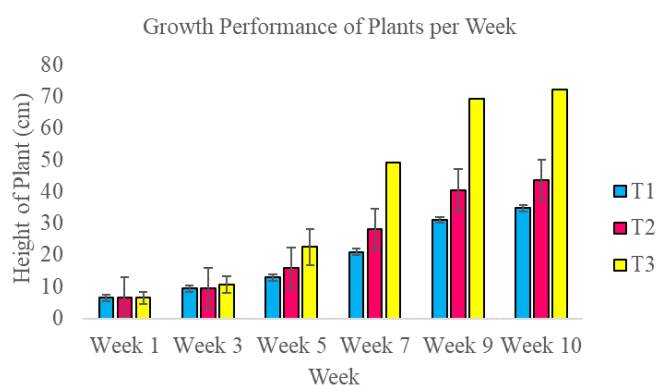


Figure 3. Growth performance of plant per week

### 3.9 Number of fruits

Based on Figure 4, treatment T3 has the highest mean value of fruit number which is 9.80 for yield value index. This followed by the treatment T1 with the mean value for yield index at 8.20 and treatment T2 has the lowest mean value at 2.80 for yield value index. To study the significant differences between treatment T1, T2, T3, the significant value had been compared with P-value

whereby  $P < 0.05$ . Thus, it shows that the significant value is smaller than the P-value. Hence, there is a significant difference between each treatment. Oshunsanya (2010) stated that okra yield difference was due to the fertility status of the soil. Several factors influence soil fertility for example soil pH, presence of organic matter, moisture content, the antagonistic effect of another nutrient and more.

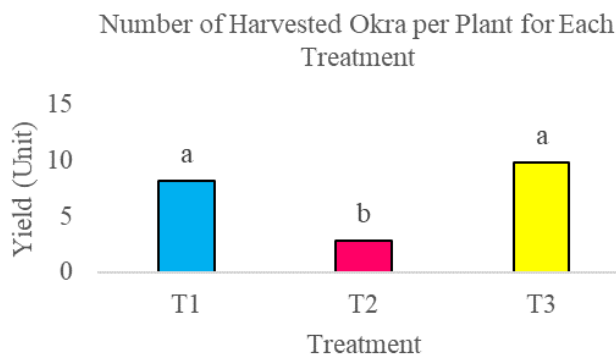


Figure 4. Number of fruits for three different types of soils. Different letters above the bar indicate significant difference.

### 3.10 Fresh weight

Figure 5 has shown that the treatment T3 showed the highest mean value for the fresh weight of harvested okra index at 32.41 g and this followed by treatment T1 at 19.19 g. The treatment T2 had the lowest at 4.69 g for fresh weight of harvested okra index. In order to study the significant differences between the treatments T1, T2, T3, the significant value had been compared with P-value which is  $P < 0.05$ . Thus, it shows that the significant value is smaller than the P-value. Hence, there is a significant difference between each treatment (refer to Table 2). Compared to other treatments, treatment T2 produced deformed fruits that influence the fresh weight of harvested okra. Klatt *et al.* (2014) stated that the weight of the fruit decreased due to deformation, where highly deformed fruits were much lighter. Okra fruits that were produced by treatment T2 become dwarfed and malformed due to the attack of pests such as the Southern green stink bug. This insect ingests the sap

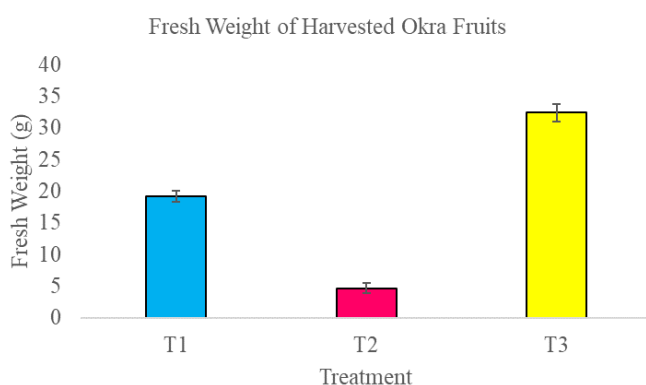


Figure 6. fresh weight of harvested okra fruits

from the leaves and seeds, resulting in them being twisted and deformed them (Albert, 2019). Insects feed on plants by penetrating the epidermis and extracts the sap from the cells. Although the insect feeds on the outer part of the plant, only its internal and liquid portions of the plants are eaten. This occurs due to its high nutrient content especially of calcium and magnesium that can be a source of attraction in taste and colour for pests.

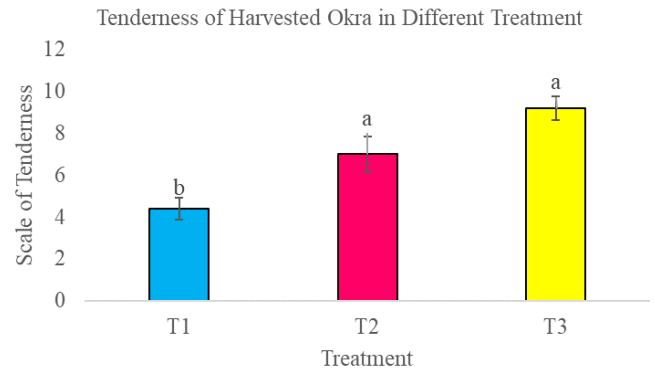


Figure 5. Value for tenderness indicator of harvested fruits. Different letters above the bar indicate significant difference.

### 3.11 Length and diameter of harvested fruits

Based on Figures 6 and 7, treatment T3 has the highest mean value of 17.18 m for length and 19.42 mm for the diameter of harvested okra index. This is followed by treatment T1 which is mean value for the length of harvested okra index of 14.67 cm while its diameter is 15.31 mm and treatment T2 had the lowest mean value of 4.4660 cm for the length of harvested okra index and 13.75 mm for diameter index. For both length and diameter of harvested okra index, to study the significant differences between the treatments T1, T2, T3, the significant value had been compared with P-value whereby  $P < 0.05$ . Thus, it shows that the significant value is smaller than the P-value. Hence, there is a significant difference between each treatment. Arora *et al.* (1991) and Naik and Srinivas (1992) stated that the application of N and P significantly improves the pod duration in okra. This might be attributed to the increased availability of NPK at the critical stages of

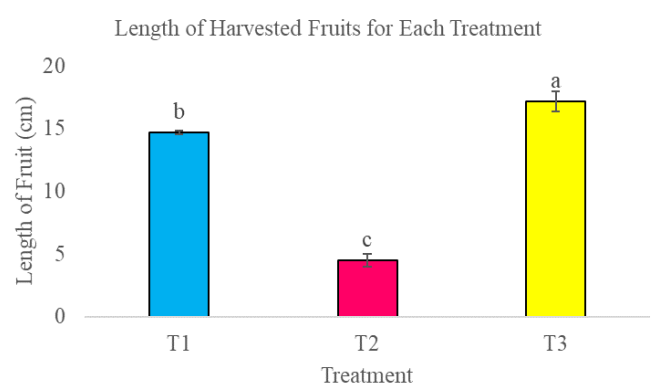


Figure 7. Length of fruit (cm). Different letters above the bar indicate significant difference.

crop growth early establishment, vigorous growth and development. On the other hand, treatment T2 showed the shortest length measurement of harvested okra index. This is because okra fruits that were produced by treatment T2 became dwarfed and malformed due to the attack of pests especially insects that feed on its leaves and fruit (Albert, 2019).

### 3.12 Colour of okra

All fruits produced by trees that were planted on treatment T3 were green or dark green. In treatment T3, the growth of its fruit was found to be the most promising yield along with other qualitative and quantitative characteristics. Dark green colour fruits of okras are the most desirable trait. Meanwhile, all fruits produced by trees that were planted on treatment T2 had green and mostly yellowish-green. Next, for T1, the fruits produced had a variation in colours with slightly yellowish-green colour and mostly green and dark green colour. Table 3 shows the colour result.

Table 3. Colour of fruits for each treatment based on colour index. Fruit colour scale; 1 = yellowish green, 2 = green and 3 = dark green.

| Treatment    | T1R1 | T1R2 | T1R3 | T1R4 | T1R5 |
|--------------|------|------|------|------|------|
| Fruit Colour | 2.67 | 3    | 2    | 2.33 | 1.67 |
| Treatment    | T2R1 | T2R2 | T2R3 | T2R4 | T2R5 |
| Fruit Colour | 2    | 1.67 | 2    | 1.33 | 1.33 |
| Treatment    | T3R1 | T3R2 | T3R3 | T3R4 | T3R5 |
| Fruit Colour | 3    | 2.67 | 3    | 2    | 2.67 |

### 3.13 Tenderness of harvested fruits

Figure 8 shows the treatment T3 has the highest mean value of 9.2 for tenderness index. This is followed by T2 which mean value for tenderness index is 7.0 and T1 has the lowest mean value of 4.4 for tenderness index. Tenderness index between 8 to 10 is optimum for okra. Size, flavour, tenderness, texture and colour can all be influenced by harvesting time (Ramjan and Ansari, 2018). High levels of magnesium will improve fruit firmness. Through decreased leakage across cell wall membranes, the skin and flesh are less likely to display breakdown disorders. A good supply of Mn slows

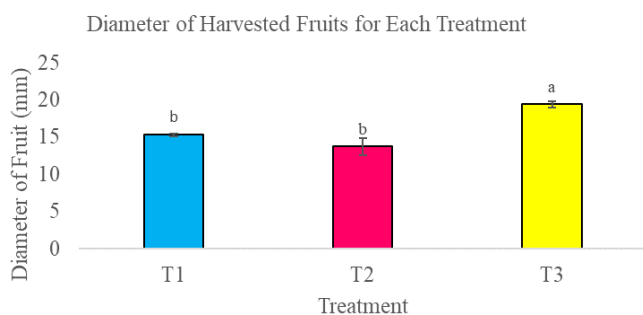


Figure 8. Diameter of harvested fruit for three treatment (mm). Different letters above the bar indicate significant difference.

ripening and improves fruit storability (Yara, 2012).

## 4. Conclusion

As a conclusion, soils play a direct and vital role in influencing the yield and quality of harvested okra. Soil provides the support or foundation for plants and most of the nutrients. It is important to understand suitable soil-based conditions as a growing media for crop production because it will influence the quality and yield of crop productivity. The results show that okra planted on alluvial soil has high yield productivity and good quality okra fruits that are demanded by the mass market. It is necessary to improve the soil characteristics whether physically or chemically to achieve the desired yield of growth and okra characteristics.

## Conflict of interest

The authors declare no conflict of interest.

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