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EFFECT OF TILLAGE METHODS ON YIELD AND GROWTH PERFORMANCES OF TWO MAIZE VARIETIES IN SANDY- LOAM SOIL IN OWERRI IMO STATE NIGERIA

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ABSTRACT

The effect of tillage methods on yield and growth performances of two maize varieties in sandy loam soil in Owerri, Imo State was studied. The results of the study were statistically analyzed using randomized complete block design (RCBD). The least significant difference was determined at $P < 0.05$ level to the test difference between four main treatments; ploughing T_1, harrowing T_2, ploughing and harrowing combination T_3 and no-till T_4 with white and yellow maize P_1 and P_2 respectively were considered within each tillage methods. The estimated marginal mean for plant height (cm) was recorded; for ploughing operation (152.45cm for white maize and 151.06cm for yellow maize), for harrowing operation (148.36cm for white maize and 147.65cm for yellow maize), for ploughing and harrowing combination (154.66cm for white maize and 153.56cm for yellow maize), for no-till (147.84cm for white and 145.64 cm for yellow maize). The results showed highest values were recorded for ploughing and harrowing combination, followed by ploughing operation, harrowing operation and lastly no-till. Also, the white maize variety recorded higher values for maize height (cm) at maturity, stem girth (cm), grain weight (g), number of grain per ear, maize weight (g) and maize yield (t/ha); as follows 154.66cm, 4.55cm, 235g, 543, 42.34g, and 12.24t/ha respectively for ploughing and harrowing combination as against yellow maize variety of 153.56cm, 4.35cm, 234g, 541, 40.25g, and 10.11t/ha respectively. The study therefore recommends ploughing and harrowing combination method for increase production of maize.

Keywords: Tillage, maize varieties, tillage methods, treatments, sandy-loam soil

1.0 INTRODUCTION

Maize is a globally significant cereal crop that serves as a staple food for millions of people and a vital feed source for livestock (Tandzi and Mutengwa, 2020). The cultivation of maize or corn from the seed stage to the marketing of the harvested produce is one of the most popular types of crop cultivation or farming in Nigeria (Kamara, *et al.*, 2021). Maize is a major cereal crop and one of the most important food crops in Nigeria as well as a dominant cereal crop in the Guinea and Sudan Savanna of Northern Nigeria (Kamara *et al.*, 2011). There are maize farmers in Ogun, Oyo, Lagos, Imo, Abia, Rivers, Kebbi, Kano, Kaduna, Niger, Edo, Delta and all the states in Nigeria (Iken and Amusa, 2004). Cultivation of maize spans diverse agroecological regions, making it a crucial contributor to food security and rural livelihoods worldwide (Adenola and Akinwumi, 2013). To meet the growing demand for maize due to population growth and changing dietary patterns, optimizing maize yield has become a priority for sustainable agriculture (Ranum, *et al.*, 2014). Modern agricultural practices are crucial for ensuring food security and sustainability as the global population continues to rise (Tandzi and Mutengwa, 2020). Among these agricultural practices, tillage plays an integral component that significantly impacts crop yield (Smith, *et al.*, 2021). Tillage methods encompass a range of soil manipulation techniques, including conventional

tillage, reduced tillage and no-till, each with distinct effects on soil structure, nutrient distribution and water retention (Shankeel, *et al.*, 2019). For increased nutrient use efficiency of crop and good crop yield, numerous factors, such as attack of pests, diseases, weed and climatic changes hampered yield of maize but tillage is the most imperative factor that could reverse the trend (Safeer, *et al*., 2013). Furthermore, tillage activity has positive effect on the soil organic matter (SOM) content, as it can increase aeration of soil, encourage decomposition of residue, organic nitrogen mineralization and availability of nitrogen for plant use (Zhang, *et al*., 2018). David, *et al*., (2007) described tillage method in crop production as mechanized approach for optimizing crop yield by utilizing tillage elements to accomplish some series of farm activities such as seedbed preparation, seed placement, incorporation of nutrients and other amendments, crop management of water and pests (Agbede, *et al*., 2008). They also inferred that tillage has direct and indirect impacts on water, soil and air quality. Tillage influences a number of biophysical processes which play a vital role in the environment. These processes include: wind, water and tillage compassion, leaching and runoff, pesticides absorption and degradation, greenhouse gas emission and soil carbon sequestration (USAID, 2013).

Tillage methods play a crucial role in modern agricultural practices, influencing soil preparation, nutrient availability, weed control, and overall crop productivity (Singh, *et al.,* 2008). The selection of appropriate tillage method is particularly important when dealing with specific soil conditions, such as sandy loam soils. Sandy loam soils are characterized by their coarse texture, which results in rapid water drainage, low water-holding capacity and reduced nutrient retention (Ali, *et al.*, 2018), Scanpare, *et al.,* 2019). These soil conditions present unique challenges for crop cultivation, including maize production. Conventional tillage operations involve series of steps to prepare the soil for planting, intensive ploughing and soil inversion, has been conventionally practiced to control weeds and prepare a suitable seedbed (Al-Kaisi and Yin, 2005). Maize is one of the most important cereal crops globally, serving as a staple food and feed source (Ranum et al., 2014). However, its successful cultivation in sandy loam soils requires careful consideration of tillage operations and the selection of suitable maize varieties (Iken and Amusa, 2004). Different tillage methods, such as conventional tillage; ploughing, harrowing, ploughing and harrowing combination, and no-till have different effects on soil structure, moisture retention, nutrient availability and maize growth and yield (Bahadar, *et al*., 2007) Understanding the impact of these tillage methods on maize growth and yield is crucial for optimizing production in sandy loam soil. The choice of tillage methods can significantly affect crop performance in various soil types (Ahaneku and Onwualu 2007). However, there is a need for further investigation specifically focusing on sandy loam soils and their interaction with maize cultivation and their varieties. By evaluating the effects of different tillage methods on the yield and growth performances of two maize varieties in sandy loam soil, this study aims to provide valuable insights into the growth and yield optimization of white and yellow maize production in such study area and environment (Abagaudura et al 2017). Understanding the influence of tillage methods on maize growth and yield performances in sandy loam soils can contribute to sustainable agriculture by enhancing productivity, conserving soil resources and minimizing environmental impacts. Additionally, this

research can help farmers and agricultural practitioners make informed decisions regarding tillage methods and maize variety selection to maximize yields and profitability (Ali et al. 2018).

The most limiting factors for sustainable maize production in small holder farm systems of Sub-Sahara Africa like Nigeria are erratic and unpredictable rains and low fertility (Ademola and Akinwumi, 2013). The major causes of low soil fertility are low levels of nutrient inputs, continuous cropping, overgrazing, deforestation and poor soil and water conservation measures (Buah, *et al.*, 2017). The situation is further aggravated by increased population pressure and limited availability of fertile land. Given the growing demand for food and feed production in a changing climate, sustainable interventions are critically required to increase maize productivity while conserving the natural resource base and preventing further degradation that has characterized most soils in Nigeria. It is essential to select a tillage method that sustains the soil physical properties required for successful growth and yield of maize in Owerri, Imo State. Therefore, more information is needed on the effect of tillage methods in maize production.

Maize also commonly referred as corn has been considered a unique plant since the time that the indigenous people of the America developed it to be their staple food (Zulfigar et al., 2017). It is a major staple cereal crop due to its high value as it has nutritional status. Maize was introduced from the new world to the old world in the 1400's and it was planted as a summer crop between the harvesting of spring and winder crops, in countries where there are few seasons differently (Adenola and Akinwumi, 2013). The USA is the world's largest producer and exporter of maize (Ranum et al., 2014), and it is the most important feed grain because of its efficient conversion of dry substance to meat, milk, and eggs, compared to other grains (Tandzi et al., 2020). Maize is the most important grain crop in Nigeria and is produced throughout the country under diverse environments. Successful maize production depends on the current application of production inputs that will sustain the environment as well as agricultural production. In developed countries, maize is consumed mainly as second-cycle produce, in the form of meat, eggs and dairy products. In developing nations maize is consumed directly and serves as staple diet for some 200 million people (Plessis, 2003). Maize or corn is cereal crop that is grown widely throughout the world in a range of agroecological environmental (Plessis, 2003). More maize is produced annually than any other grain. More than 50 varieties are in existence and consist of different colours, textures and grain shape and sizes. The white and yellow varieties are the most common types and are predominantly preferred by many people in different regions. Maize was introduced into Africa in the 1500s and has since become one of Africa's dominant food crops (Alhassan, 2021). Like many other regions, it is consumed as a vegetable although it is a grain crop. The grains are rich in vitamins A, C and E, Carbohydrates and essential minerals and contain 9% Protein. They are also rich in dietary fiber and calories which are a good source of energy.

Rajanikanth, *et al.*, (2024) opined the effect of tillage practices and hydrogen applications on maize yield in sandy loam soils at the Agricultural Research Station, Karimnagar, Telangana in India, over a period of four years (2015 – 2018) during the Kharf Season with four main treatments: conventional tillage CT, conventional tillage with residual mulching CM, and zero tillage with

residual mulching ZM, followed with three sub-treatments involving hydrogel applications; control (no hydrogel), Hydrogel at 2.5kg/ha and Hydrogen at 5.0kg/ha. The study was replicated thrice and the results showed that the combination of zero tillage with residue mulching ZM yielded the highest maize grain (4435kg/ha). The addition of hydrogel, regardless of the rate (2.5kg/ha or 5.0kg/ha) did not lead to any significant improvement in maize yield. Li Fan, *et al.*, (2024) conducted experiment on effects of arbuscular mycorrhizal fungi (AMF) on maize yield and soil microbial community in sandy and saline-alkali soils. The study observed treatment of AMF application and no AMF application were used on the soil microbial community structure and the correlation between soil microbes and soil physio-chemical properties were analyzed. The results revealed that under both sandy and saline-alkali soils, AMF application significantly enhanced maize growth and yield compared with the no AMF application treatment. The study demonstrated that the use of AMF as a bio-fungi fertilizer was effective in improving maize yield especially in terms of yield increase and quality stability in sandy and saline-alkali soils, thereby contributing to safe and sustainable cropping practices. Usman, *et al.,* (2017) studied the performance of maize yield and quality under different irrigation regimes and nitrogen levels at agronomic research area, University of Agriculture Faisalabad, Punjab, Pakistan in spring 2015. The study used Randomized Complete Block Design (RBDC) with split plot arrangement and replicated three times, the plot size was 5m x 1.8m ($9m^2$) having four rows in every plot levels of irrigation were assigned in main plot and nitrogen levels in subplots which had sixteen treatments: I_1 (eight number of irrigation levels), I_2 (50mm potential soil moisture deficit) and nitrogen levels were found to be significant and opined that full irrigation with N_4 (175kgN/ha) produced the highest 1000grain weight (g), economical yield, total matter production (t/ha) and harvest index oil content (%) was significantly affected by nitrogen levels. Ahaneku and Dada (2013) conducted field experiment to evaluate the effect of four different tillage methods and temporal factor on soil physical properties of a sandy loam soil. The tillage treatments in the study were conventional tillage (disc plough followed by one pass of disc harrow (PH) and disc plough followed by two passes of disc harrow (PHH) and conservation tillage (No-till and disc plough alone (PA)). Results were analyzed and it was found that conventional tillage practices showed better soil moisture conservation and higher porosity than No- tillage method.

Bongomin, *et al.,* (2020) conducted a study on evaluation of maize under minimum and conventional tillage practice in two distinct agroecological zones of Uganda where the tillage practices (conventional tillage CT and minimum tillage MT) as the main factors and two maize varieties (Longe 10H and Longe 5H) as the levels. The results showed significant differences in plant height between the two tillage methods ($P<0.001$). Conventional tillage practice had a higher mean maize grain yield per hectare compared to minimum tillage although the difference was insignificant ($P<0.332$). They observed a higher maize grain yield for conventional tillage practice compared to minimum tillage although the yield difference was insignificant. Ahaneku and Onwualu (2007) studied the effects of six tillage methods on soil physical properties of maize germination, growth and yield were evaluated in field experiments for 1995 and 1996 cropping seasons, crop performance varied due to the imposed tillage treatments with the exception of no-

tillage method. The conventional tillage methods in term of maize germination growth and yield performed better than no-tillage method. A study by Aikins and Afuakwa (2010) observed that the conventional tillage practices of disc ploughing alone, combination of ploughing and harrowing registered higher mean stem girth compared to the no tillage practice in cowpea rainfed field of Kumasi region in Ghana. Paramu, *et al*., (2016) also observed that Zero tillage practice resulted in lower maize grain yield, higher bulk density, reduced water intake, higher weed infestation and high labour demand during weeding compared to conventional tillage. Conventional tillage improved the soil environment and resulted in increased maize yield in all cropping systems.

The general objective of this research was to examine the effect of tillage methods on the yield and growth performances of two maize varieties in sandy loam soil in Owerri, Imo State by determining the effect of tillage methods on the growth performance of white and yellow maize in sandy-loam soil and comparing these varieties of maize with better yield performance under different tillage methods.

2.0 METHODOLOGY

2.1 Experimental Site

The experimental site was located at the Federal Polytechnic Nekede Owerri (FEDPOLNEK) demonstration farm which lies within latitude 5^0 26'N and longitude 7^0 2' E. The area of the land selected was 100m x 100m or 10,000m^2, the land was sub-divided into small plots of 25m x 25m in order to accommodate the planting of the two varieties of maize (white and yellow maize). The planting distance was 0.75m x 0.75m and planting depth was 0.05m measured with steel rule, from the emergence of the plant to the shooting out of the leaves, measurements were taken. The stem girth of maize was measured from the base of the plant just above the soil surface with flexible measuring tape or string and a ruler. The tape or string was wrapped around the stem and the circumference was recorded; the leaf numbers were counted from fully emerged leaves with visible collar (where the leaf meets the stem) excluding the first leaf (coleoptile). The growth parameters were determined by the maize height (measure from the soil surface to the base of the tassel, the leaf area index (LAI) measured using the leaf length done with string, leaf width and leaf number. The yield parameters were measured; ear weight, grain weight using weighing balance, grain moisture content measured with weighing balance and oven dried in the laboratory, and number of ears per plant by counting the ears per plant. The experimental site was chosen based on its sandy loam soil characteristics, accessibility, previous cropping history and drainage were considered to ensure the site was representative for such experiment.

2.2 Experimental Design

The study was laid out in a randomized complete block design (RBDC) with four main treatments; ploughing alone T_1, harrowing alone T_2, ploughing + harrowing combination T_3, and No-tillage T_4, two varieties of maize; white P_1 and yellow P_2 (as the levels) were randomly assigned to the respective tillage treatments with three replications and one location at FEDPOLNEK Demonstration Farm Owerri (4x2x3x1) = 24 experimental runs. The size of each plot was (100m

x 100m) divided into plot of (25m x 25m) with inter block spacing of 1.5m and inter plot spacing of 1.5m.

2.3 Experimental Procedure

The experiment was conducted from 20th March, 2023 to 20th July, 2023 at the FEDPOLNEK Owerri. The plots were ploughed on 20th, 21st and 22nd March, 2023 while the harrow operation was done same days; 20th, 21st and 22nd March 2023, followed by Ploughing + harrowing combination on 20th, 21st and 22nd March, 2023. A 45kW (60 Hp) SWARAJ Tractor Model 978FE with three-point hitch system was used to pull the field equipment during the field operations. Disc plough and disc harrow were used for the study; the plough consists of three plane concave disc with a spacing of 680mm while the harrow consists of sixteen gang plane concave and notched concave disc harrow spaced 225mm apart. A constant speed travel of 1.8m/s was maintained for the tillage operations for the soil (sandy loam) as recommended by Ahaneku and Ogunjirin (2005). Also, the draft force required for ploughing and harrowing operations were 4.95KN and 3.77KN respectively as opined by Ahaneku and Dada (2013). For No- tillage, planting was done after slashing the soil surface. Two maize varieties (white, DMR-ESR and yellow, SAMMAZ 15) were used for the study. These varieties were selected because they are predominantly grown in the zone. The seeds were acquired from the National Root Crop Research Institute (NRCRI) at Umudike in Abia State. At the commencement of the experiment, tillage depths were measured at three random locations on each plot. A steel rule was inserted down into the tilled soil to a depth of 0.05m (5cm) which serve as the tillage depth measured from the corresponding reading on the steel rule. For all the operations 2 maize seeds per hole for planting for all the treatments. All other agronomic practices were kept normal and uniform for all treatments. Harvesting and threshing was done on 6th July, 2023 and kept in their respective plot for sun drying. Each plot yield was tied in bundle and weighed. The ears were removed from the dry stalks, unsheathed and threshed mechanically with the help of corn sheller.

3.0 RESULTS AND DISCUSSION

3.1 Soil condition and physical characteristics of the study area

The analysis of the soil test was carried out at the study site (FEDPOLYNEK Demonstration Farm). The results of the analysis test for physical properties/characteristic of the soils were presented in Table 1.

Table 1. Physical characteristics of the soil for the tillage operations

SOIL PARAMETER Soil Compositor	No-Till. (%)	Ploughing (%)	Harrowing (%)	Ploughing and Harrowing (%)
Sand	78.5	78.5	78.5	78.5
Silt	18	18	18	14
Clay	14	14	14	14
Textural Class	Sandy loam	Sandy loam	Sandy loam	Sandy loam
Average Moisture	17.4	17.4	17.4	17.4
Content (%)				
Average Bulk	1.63	1.63	1.63	1.63
Density (g/cm^3)				
Porosity (%)	51.78	51.78	51.78	51.78
Structural type	Granular	Granular	Granular	Granular

Table 1 showed the soil physical characteristics in the study area. The average moisture content was at 17.4% this is as a result of rainfall during the period of the experiment. The average bulk density was 1.63g/cm^3 and it shows that the bulk density of the study area falls within the ideal bulk density of 1.64g/cm^3 for plant growth as recommended by Oduma, *et al*., 2015. The average porosity was observed to be 51.78% and the soil structural type was generally granular with small and spherical pods indicating Sandy loam soil being predominant in the study area according to Textural triangle.

3.2 Effect of Tillage Operations on the Growth Performance of White Maize

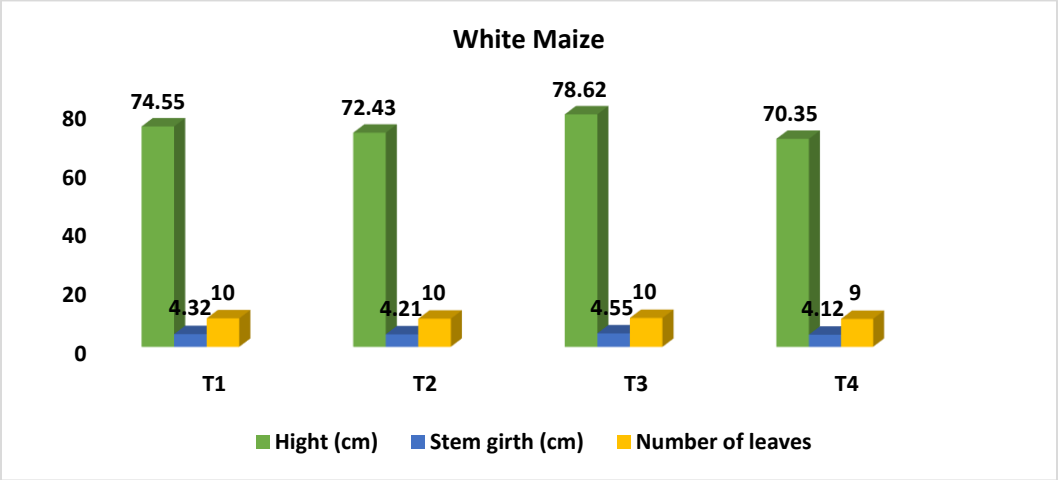


Figure 1: Effect of tillage operations on the growth performance of white maize.

Figure 1 showed that white maize recorded; highest height, stem girth and number of leaves as 78.62cm, 4.55cm and approximately 10 leaves respectively for ploughing and harrowing combination while least values of 70.35cm, 4.12cm and 9 leaves respectively for no-tillage. This is in line with Aikins and Afuakwa (2010) and Drakopoulos, *et al.*, (2016), that opined effect of tillage methods result in higher values for height, stem girth and number of leaves for ploughing and harrowing combination method than the other tillage methods under study.

3.3 Effect of Tillage Operations on the Growth Performance of Yellow Maize

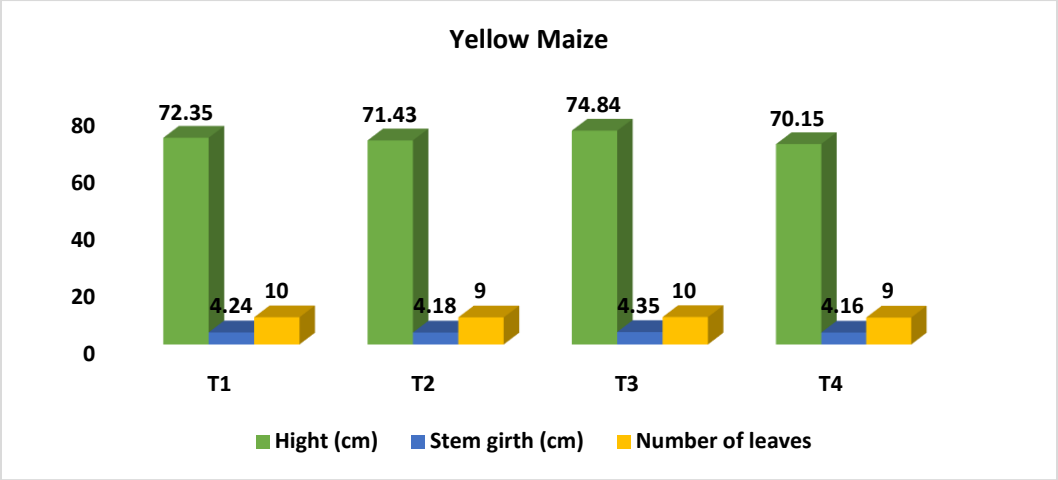


Figure 2: Effect of Tillage Operations on the Growth Performance of Yellow Maize

Figure 2 revealed that yellow maize recorded the highest height, stem girth and number of leaves of 74.84cm, 4.35cm and 10 respectively for ploughing and harrowing combination while least values of 70.15cm, 4.16cm and 9 respectively were recorded for no-tillage operation. This is agreement with Aikin and Afuakwa (2010) and Drakopoulos et al. (2016).

3.4 Effect of Tillage Operations on Yield Performance of White Maize and Yellow Maize.

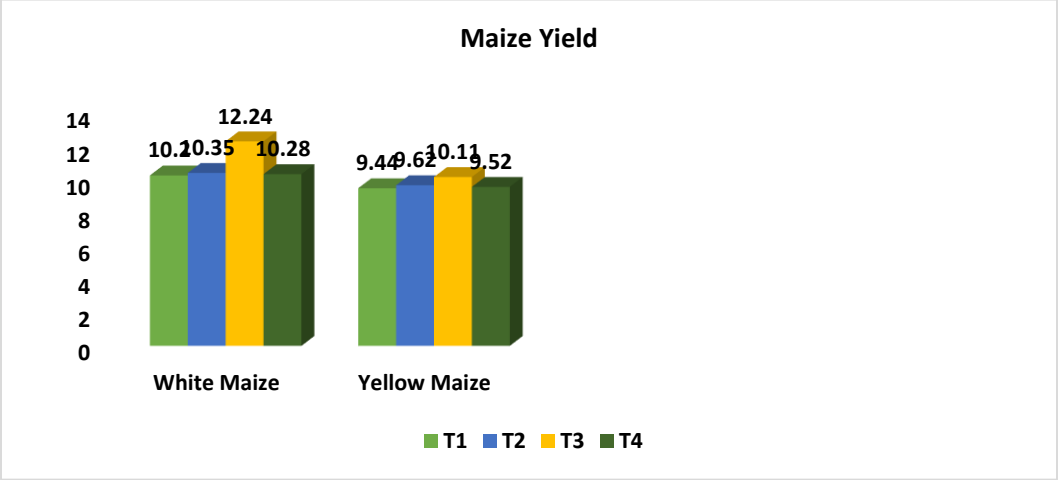


Figure 3: Effect of Tillage Operations on Yield Performance of White Maize and Yellow Maize

Figure 3 revealed that ploughing and harrowing combination method recorded the highest values of maize yield of 12.24g for white maize and 10.11g for yellow maize while least values of 10.28g for white and 9.52g for yellow were recorded for no-tillage operation. This is in agreement with Paramu et al. (2016) and Bongomin et al. (2020).

3.5 Effect of Tillage Operations on Maize Yield Performance under Study



Figure 4: Maize Yield at 14 Weeks for the Different Tillage Operations

Figure 4 revealed that white maize performed better than yellow maize, ploughing and harrowing combination recorded the highest maize yield of 12.24g and 10.11g for white and yellow maize respectively. This is in agreement with Bongomin et al. (2020) and Paramu et al. (2016). The least weight of ear was recorded against no-till of 10.18g and 9.52g for white and yellow maize respectively. This is in agreement with Bongomin et al. (2020).

3.6 Effect of Tillage Operations on Plant Height at Maturity

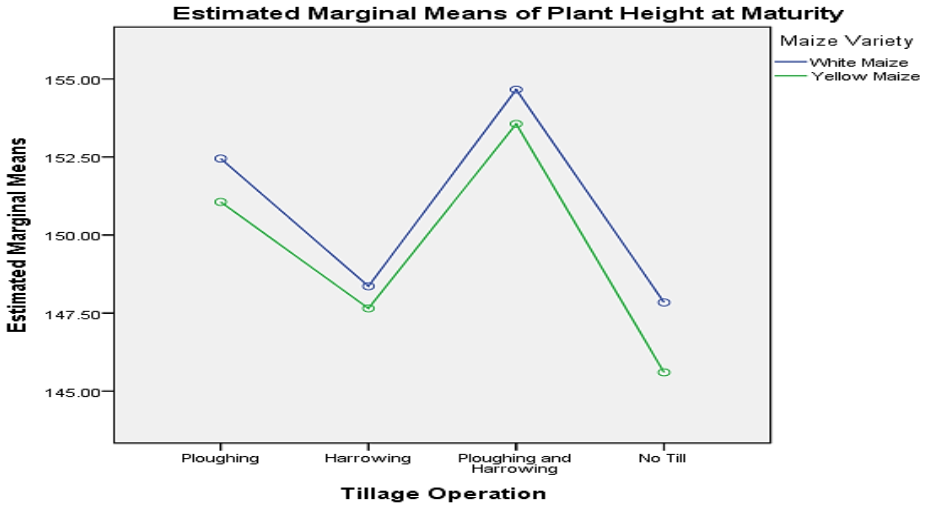


Figure 5: Effect Of Tillage Operations On Maize Height At Maturity

Figure 5 showed that the maize highest height at maturity for ploughing and harrowing combination 154.66cm and 153.56cm for white and yellow maize respectively. The least height was recorded for no-till of 147.84cm and 145.64cm respectively, for ploughing alone 152.45cm and 151.06cm respectively and harrowing alone was 148.36cm and 147.65cm for white and yellow respectively.

3.7 Effect of tillage operations on number of grains per ear

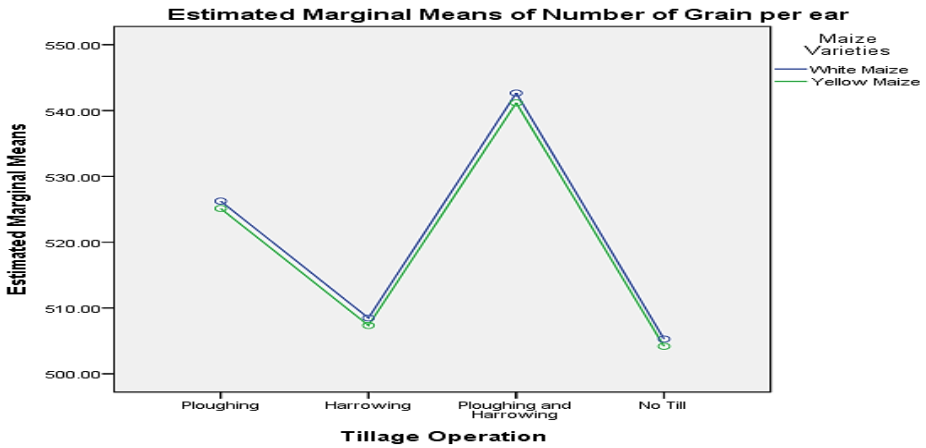


Figure 6: Effect of Tillage Operations on Number of Grains per Ear

Figure 6 revealed that under the different tillage methods the highest number of grains per ear were recorded for ploughing and harrowing combination 543 and 541 for white and yellow maize respectively. The least number of grains per ear for no-till was 505 and 504 for white and yellow respectively. Ploughing alone recorded 526 and 525 respectively compared to harrowing alone 508 and 507 respectively. The findings showed no significant effect on the number of grains per ear for both varieties except for where different tillage methods were applied. This is in line with Paramu et al. (2016).

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

The research on effect of tillage methods on yield and growth performances of two maize varieties in sandy loam soil in FEDPOLNEK Demonstration Farm Owerri, Imo State found that ploughing and harrowing combination method recorded the best effect on the yield and growth performances of white and yellow maize followed by ploughing operation alone, harrowing operation and lastly no tillage this is in line with Paramu et al. (2016) that No-tillage treatment results in lower maize growth and yield than conventional tillage. Also, the finding showed that white maize variety performed better in growth and yield than the yellow maize.

4.2 Recommendations

The study's findings would inform policy makers and agricultural organizations in formulating policies and guidelines related to tillage methods and maize cultivation in sandy loam soil. The study's finding can be disseminated through extension services to reach farmers and agricultural stakeholders, promoting the adoption of best practices for tillage methods and maize cultivation in sandy loam soil. Further study and investigation should be made on effect of tillage methods on maize cultivation in sandy loam soil. Results of the study form database that will guild farmers and agriculturists in selecting tillage methods that will suit the soil condition of the study area with similar soil and ecological conditions.

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