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Effect of Tillage Operations on Yield Performance of White and Yellow Maize Varieties in Sandy- Loam Soil: A Case Study of Fedpolnek Demonstration Farm, Owerri Imo State

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Abstract

The effect of tillage operations on the yield performance of white and yellow maize in sandy loam soil were 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 of probability 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 operation. The estimated marginal means 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 operation for increase productivity of maize.

Keywords: Tillage, maize yield, tillage operations, treatments, sandy loam soil

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, A.Y. Omoigui, L.O, Ewansiha, S.U., Abdoulaye, T., Amaza, P., Chikoye, D. and Dugje, I.Y. 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, P., Pena-Rosas, J.P., Garcia-Casal, M.N. 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 operation plays an integral component that significantly impacts crop yield (Smith, J.D., Johnson, A.B and Brown, C.J. 2021). Tillage practices 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, A.A, Muhammad, M.R, Sami, U. Malik, M.Y., Ahmad, M., Mumtaz, H. Muhammed, J.S. Bashir, A. and Ijaz, A. 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, A., Aziz, I., Mahmood, T, Akmal, M. 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 Li, Wang Jing, Guozhan Fu, Yonggan Zhan 2018). David, A.L, Edward H. and Donald, C.R. (2007) described tillage operation 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, T.M. Ojeniyi, S.O. and Awodun, M.A. 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 operations play a crucial role in modern agricultural practices, influencing soil preparation, nutrient availability, weed control, and overall crop productivity (Singh, B.K, Tate, K.R and Ross, D.J 2008). The selection of appropriate tillage operation 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, A. Usman, M.and Adaikwu, A.O. 2018), Scanpare, F.B., Van Lier Q.J, Camargo, L.D, Pires, R.C.M., Ruizcorrea, S.T., Bezerra, A.H.F., Gava, G. J. C. and Dias, C.T.S 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 operations, 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, K.M, Arif, M and Khan, M.A. 2007) Understanding the impact of these tillage operations on maize growth and yield is crucial for optimizing production in sandy loam soil. The choice of tillage operations 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 operations on the yield performance of white and yellow maize 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 operations on maize growth and yield performance 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 operations and maize variety selection to maximize yields and profitability (Ali et al. 2018).

Maize is considered one of the most important cereal crops due to its demands for consumption and industrial purpose (Abagaudura, G., Mohamed Nasr, G and Moumen, N. 2017). Low soil organic matter and pests decrease maize production worldwide (Tandzi and Mutengwa, 2020). Some farmers use various tillage operations without being aware of the effect of these systems on soil physical properties and plant growth (Ali et al., 2018). It is essential to select a tillage operation that sustains the soil physical properties required for successful growth of maize in FEDPOLNEK Imo State. Therefore, more information is needed on the effect of tillage operations on yield performance of white and yellow maize in FEDPOLNEK. 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 (Adenola 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, S.S.J., Ibrahim H. Derigubah, M. Kuzie M., segtea, J.V, Zougmore, R. Quedraogo, M 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.

Most farmers prepare the land by using hand hoe or by ploughing with tractors or draught animals. However, cultivation with the hand hoe is more common. When the soil is subjected to intensive and repeated tillage, it becomes susceptible to high run-off and soil erosion rates and soil deterioration. This results in progressive decline in soil productivity and low crop yield (Alhassan, A.RM, Chaunjie-Yang, Weiwei, Ma, Guang, Li 2021). Some of the degraded soils often exhibit a general lack of response to mineral fertilizer addition (Iken andAmusa 2004). Conservation tillage practices that leave a protective amount of crop residue on the soil surface help to control soil erosion, minimize surface crusting, reduce soil water evaporation and increase the rate of water infiltration. Surface residues maintained with no-tillage also can cause soils to remain cool and wet. The soil is mostly bare for about six months prior to the cropping season. This is even compound by the occurrence of indiscriminate annual bush fires in the dry season. Complete residue removal for fodder and fuel, and intensive and excessive tillage can deplete soil organic carbon stocks which often lead to the deterioration of soil fertility and soil water storage capacity, resulting in frequent crop failures. Farmers that use disc plough, chisel plough and ridger before planting cause the formation of plough pans in soil due to the pressure exerted by these machines while some still plant without tillage to keep the organic matter from previous year on the surface to help hold the soil in place (Miriti, J.M, Kironchi, G., Esilaba, A.O, Gachene, C.K.K, Heng, L.K and Mwangi, D.M 2013). Finally, it is essential to select a tillage practice that sustains the soil physical properties required for successful growth of maize in FEDPOLNEK. Therefore, more information is needed on the effect of tillage practice under maize production in FEDPOLNEK. The general objective of this study is to examine the effect of tillage operations on the yield performance of white and yellow maize in sandy loam soil at FEDPOLNEK, Imo State. The specific objectives are as follows; To determine the effect of tillage operations on the growth characteristics of white and yellow maize in sandy-loam soil To compare these varieties of maize with better yield performance under different tillage operations To make

recommendations to the farmers on the maize variety with better yield performance in the study area

Materials and Methods: 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 other 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 x 0.05m. From the emergence of the plant to the shooting out of the leaves, measurements were taken. 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.

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 and 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 (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.

Experimental Procedure: The experiment was conducted from 20th March, 2023 to 20th July, 2023 at the FEDPOLNEK. The plots were ploughed on the 20th March, 2023 and the harrow operation was done the next day (21st March, 2023) followed by Ploughing and harrowing combination operation on the 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 dug 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 until a characteristic hard pan was reached. The tillage depth was measured from the corresponding reading on the steel rule. For all the operations 4 maize seeds per hole for planting followed by thinning done to 2 plants each per hole for all the treatments. Irrigation was applied manually by watering can. 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.

Results and Discussion : 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 are presented in Table 1. Table 1 showed that the dominant soil in the study area was sandy loam soil. 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, O., Igwe, J.E., Ntunda, D.I., (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 according to Textural triangle.

Effect of tillage operations on the growth performance of white maize: Figure 4.1 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 operation 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 D., Scholberg J.M., Lantinga E.A, Tittonell, P.A (2016), that opined the effect of the tillage operation which results in higher values for height, stem girth and number of leaves for ploughing and harrowing operation than the other tillage operations under study.

Effect of tillage operations on the growth performance of yellow maize: Figure 4.2 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 operation 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).

Effect of tillage operations on weight performance of white maize and yellow maize.: Figure 4.3 showed that ploughing and harrowing operation recorded the highest value of maize weight of 42.34g for white maize and 40.25g for yellow maize for ploughing and harrowing combination while least values of 33.26g and 33.15g respectively for no -tillage operation. This is in agreement with Paramu et al. (2016) and Bongomin et al. (2020).

Effect of tillage operations on yield performance of white maize and yellow maize: Figure 4.4 revealed that ploughing and harrowing combination operation 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).

Effect of tillage operations on the length of ear development of maize under study: Figure 4.5 showed the effect of different operations on the ear development of maize

under study, white maize performed better than yellow maize across all the tillage operations, Ploughing and harrowing combination recorded the highest length of ear of 13.86cm and 11.34cm for white and yellow maize respectively at the 14th week. This is in agreement with Paramu et al. (2016). The least length of ear of was recorded against no-till of 12.24cm and 10.53cm for white and yellow maize respectively. This is in agreement with Aikins and Afukwa (2010).

Effect of tillage operations on the diameter of ear development of maize under study: Figure 4.6 revealed that white maize performed better than yellow maize across all the tillage operations; for ploughing and harrowing combination recorded the highest diameter of ear of 2.58cm and 1.98cm for white and yellow maize respectively. This is in agreement with Paramu et al. (2016). The least diameter of ear was recorded against no-till of 1.22cm and 1.05cm f or white and yellow maize respectively. This is in agreement with Bongomin et al. (2020).

Effect of tillage operations on the weight of ear development of maize under study: Figure 4.7 revealed that white maize performed better than yellow maize across all the tillage operations; for ploughing and harrowing combination recorded the highest weight of ear of 16.54kg and 14.36kg 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 14.25kg and 13.48kg for white and yellow maize respectively. This is in agreement with Bongomin et al. (2020).

Effect of tillage operations on maize yield performance under study: Figure 4.8 revealed that white maize performed better than yellow maize for 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).

Effect of tillage operations on plant height at maturity: Figure 4.9 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.

Effect of tillage operations on number of grains per ear: Figure 4.10 revealed that under the different tillage operations the highest number of grains per ear was 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 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 operations were applied. This is in line with Paramu et al. (2016)

Conclusion : The research on effect of tillage operations on yield performance of white and yellow maize varieties of maize in sandy loam soil, a Case Study of FEDPOLNEK Demonstration Farm Owerri, Imo State found that ploughing and harrowing combination operation recorded the best effect on the yield performance of both 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.

Recommendations: The study's findings can inform policy makers and agricultural organizations in formulating policies and guidelines related to tillage operations and maize cultivation in sandy loam soils. The study's finding can be disseminated through extension services to reach farmers and agricultural stakeholders, promoting the adoption of best practices for tillage operations and maize cultivation in sandy loam soil The study recommends a further study on tillage operations and maize cultivation in sandy loam soils.

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

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

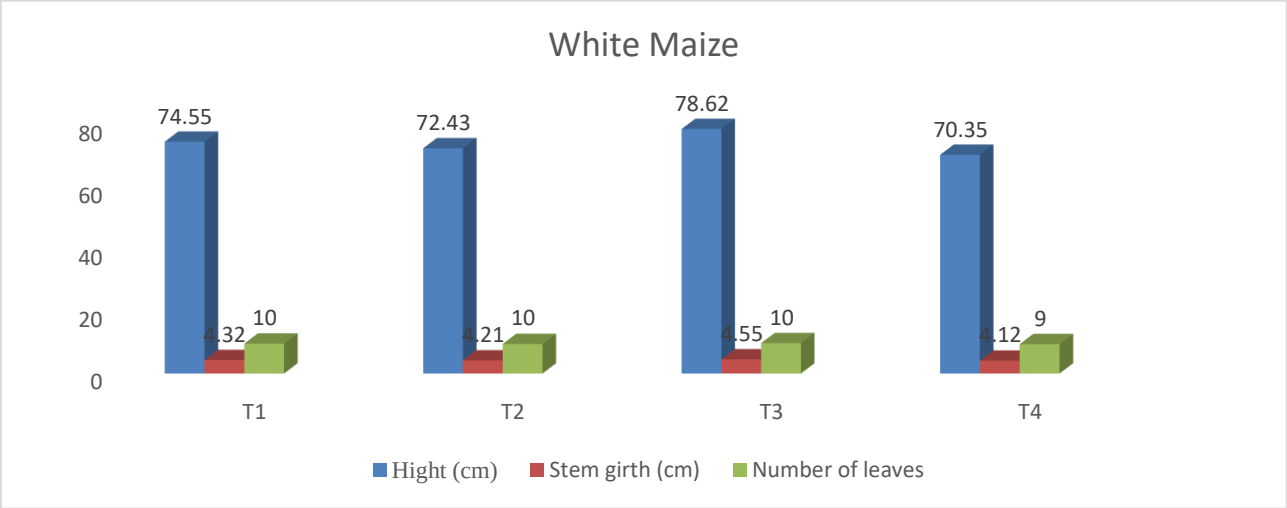


Figure 4.1: Effect of tillage operations on the growth performance of white maize.

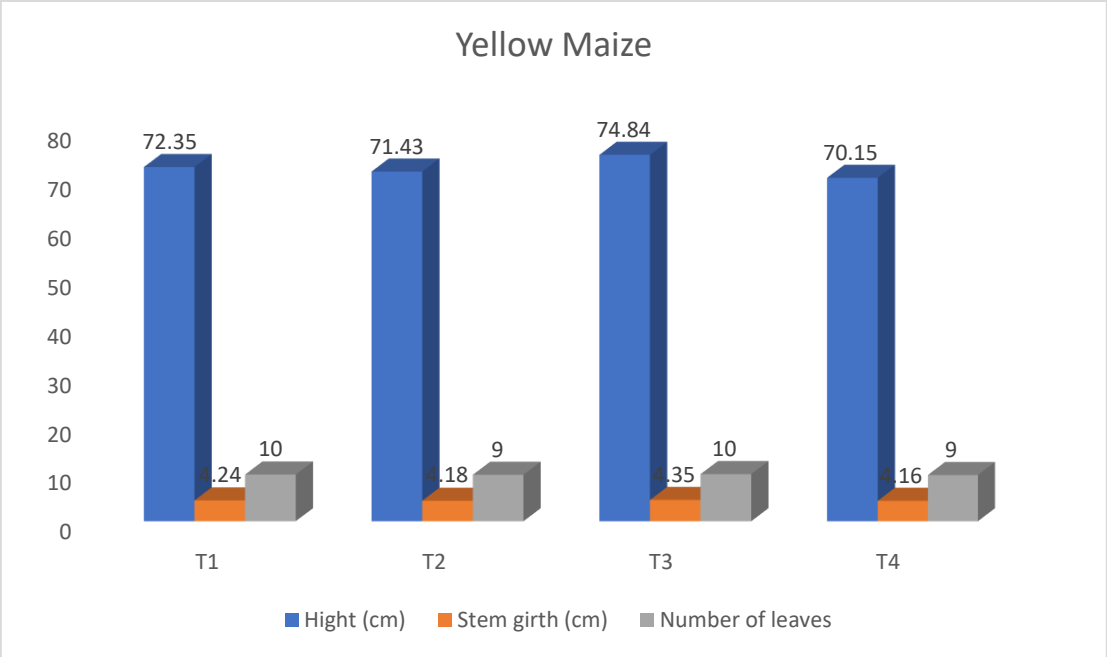


Figure 4.2 Effect of tillage operations on the growth performance of yellow maize

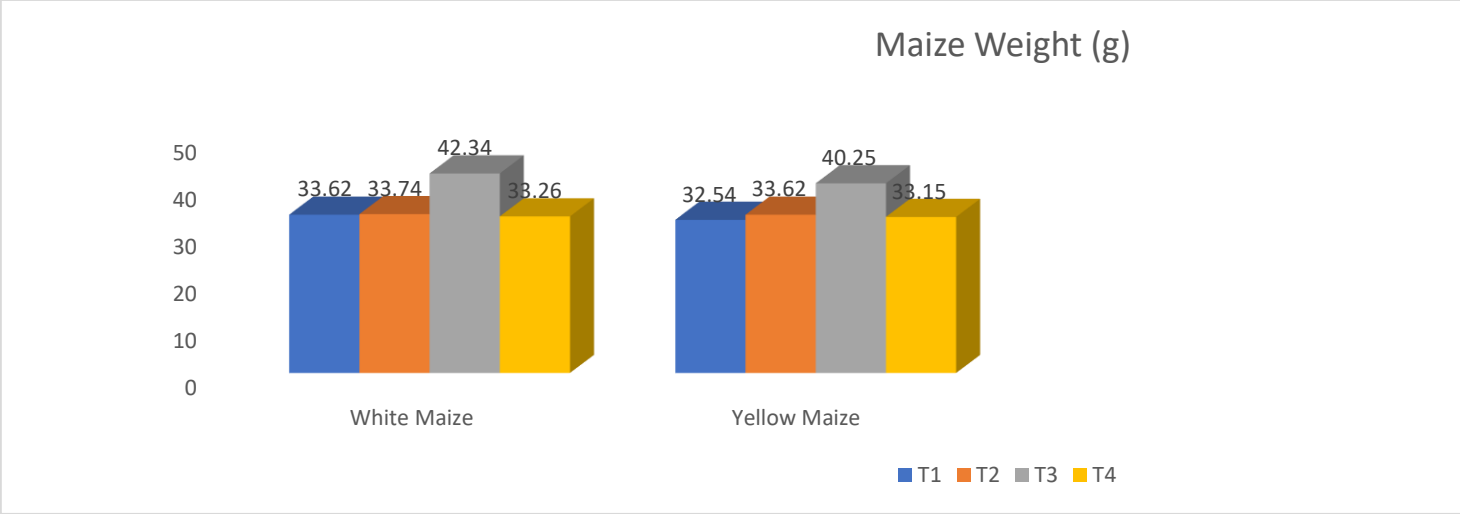


Figure 4.3: Effect of tillage operations on weight performance of white maize and yellow maize.

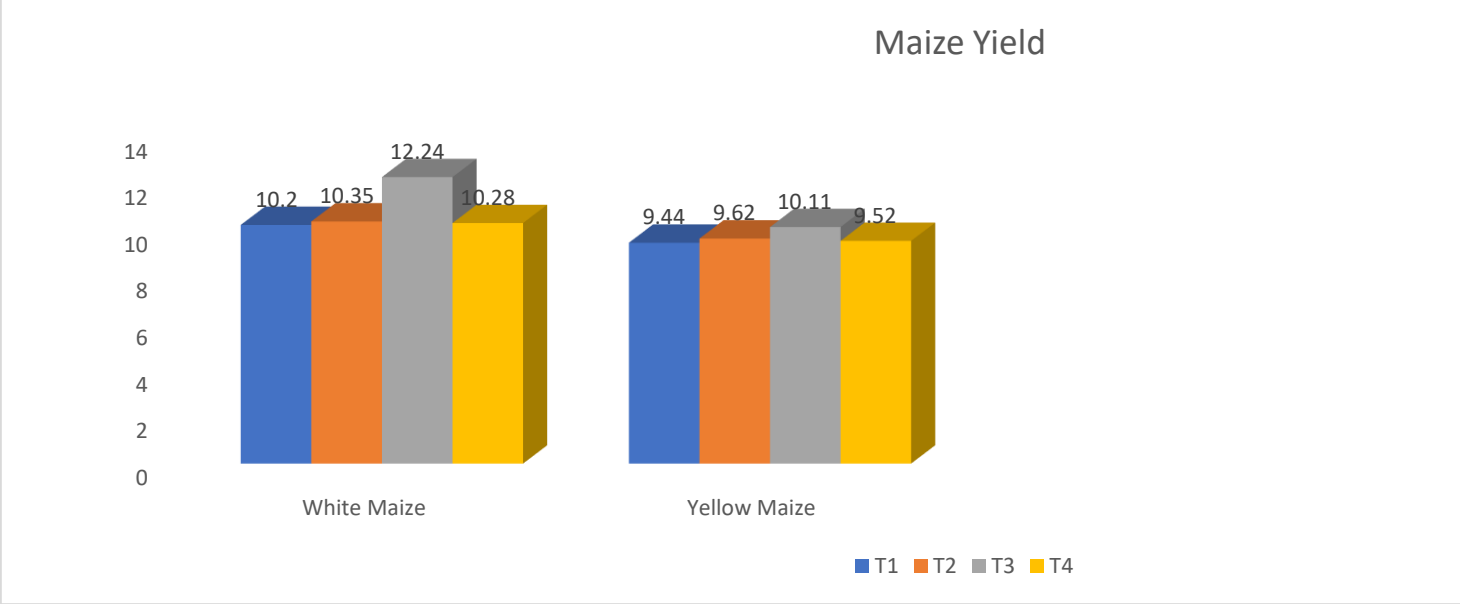


Figure 4.4: Effect of tillage operations on yield performance of white maize and yellow maize.

Figure 4.5 Length of maize ear(cm) at 14 weeks for the different tillage operations

Figure 4.6 Diameter of ear(cm) at 14 weeks for the different tillage operations

Figure 4.7 Weight of ear (g) at 14 weeks for the different tillage operations

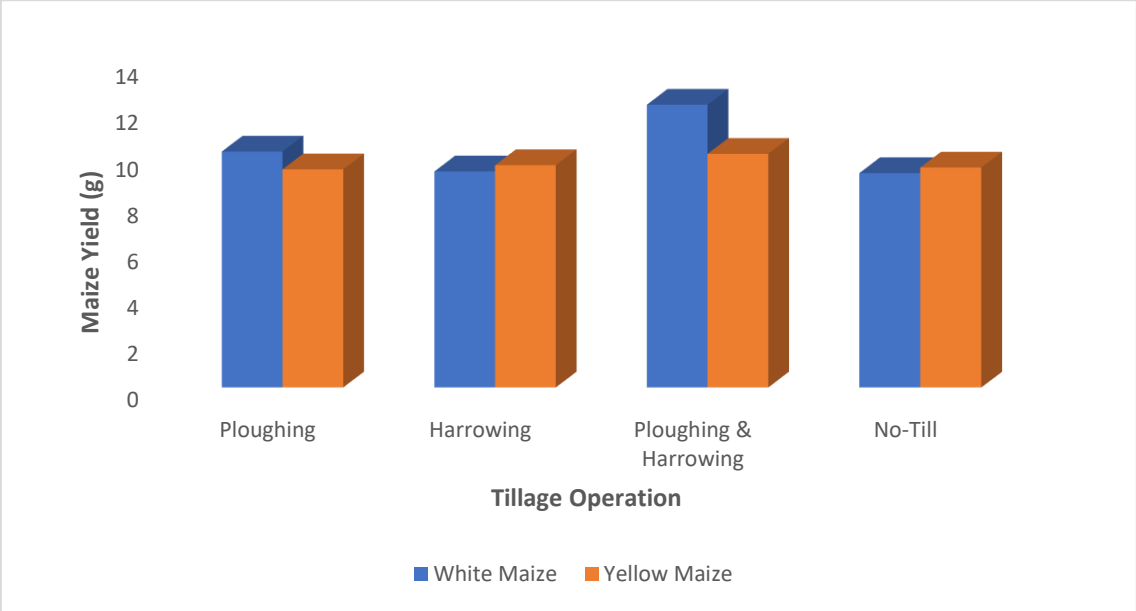
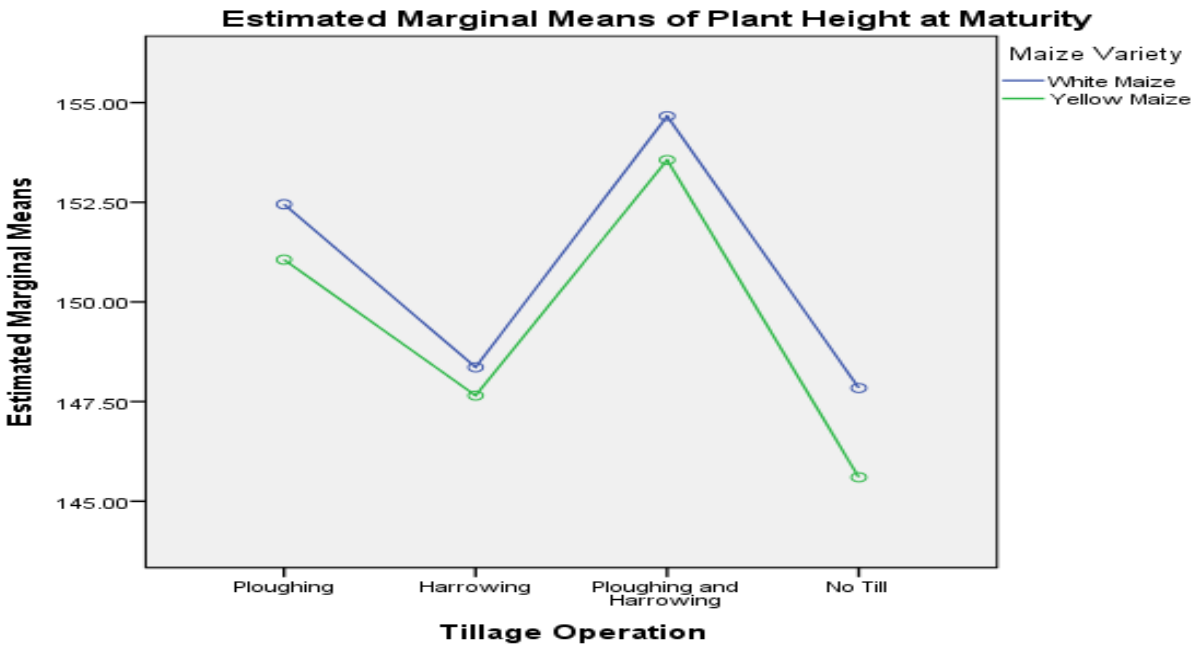


Figure 4.8 Maize yield at 14 weeks for the different tillage operations



4.9 Effect of tillage operations on maize height at maturity

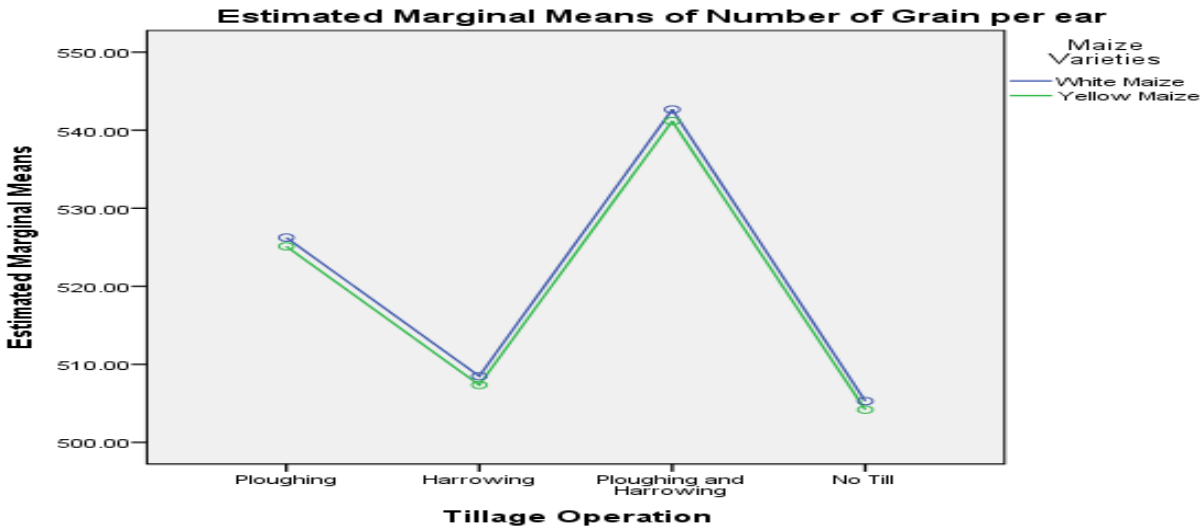


Figure 4.10: Effect of tillage operations on number of grains per ear