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EFFECT OF DEPTHS OF TILLAGE ON THE PERFORMANCES OF OPEN-POLLINATED YELLOW MAIZE (*ZEA MAYS*) VARIETIES

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Key words: tillage depth, maize, leaves number, plant heights, silking, yield component.

Abstract

The study investigated the depths of tillage on the yield of open-pollinated maize (*Zea mays*) varieties. Eighteen compartmental plots of 400 m^2 at 4 m × 10 m; 2 m apart, each comprising 2 depths of tillage (0–15 cm and 0–30 cm), 3 open-pollinated varieties (OPV 1, OPV 2, OPV 3), each replicated thrice (2 × 3 × 3 factorial design) were experimented. Data collected were days to emergence of seeds, plant height, the number of leaves/plant, days to 50% anthesis (DAT), days to 50% silking (DAS), Anthesis-Silking Interval (ASI), Leaf Area Index (LAI), grain yield (GY)/ha. There were no statistical differences for the number and length of leaves and DAT, there were statistical differences for plant heights, DAS, LAI, stem girth and ASI. OPV 3 had the highest number of leaves, plant height, stem girth, while OPV 2 had the highest mean value for LAI and DAT. Depth 0–15 cm was adjudged the best in the study.

Introduction

Maize production in Nigeria over the years has been decreasing, as against the increase in the country's population, this necessitated the government to import maize for both man and animals' consumption (MOJEED 2020). This decrease in supply and production may not be unconnected with environmental and soil factors, crop management techniques and some government policies.

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Compared to the world, Nigeria has not been doing well in maize production rate as compared with the global figures. As of 2019, maize production in the United States of America was 347,047,570 tonnes, China 260,957,662 tonnes, Brazil 101,138,617 tonnes and Nigeria had 110,000,000 tonnes (WITS 2021, FAOSTAT 2020, NUEweb. 2012). Factors responsible for this low production in Nigeria could not only be because of global climate change, but also management, non-usage of soil enhanced materials, nature of seeds and other production strategies that may be peculiar to African states. The question now is, what could have happened to Nigeria that made her maize production rate dwindle over time? Likely factors from locality may also be the depth of tillage, depth of sowing, planting of varieties that were not adaptable to local climate, management efforts of the husbandry and others (Pittelkow et al. 2015, Oladejo and Adetunji 2012).

The ultimate goal of agricultural production is high yield which has a direct relation with measures of tillage. When tillage is improper, it can cause severe land degradation, and low yields (Doni et al. 2017). Many scholars who have dealt with tillage have also considered the negative effects of tillage on the plant, i.e. its ability to increase the rate of water runoff; the over-tilling effect on soil structure; decrease in soil-water infiltration rate, dislodging the cohesiveness of the soil particles and inducing erosion; reduction in soil organic matter and destruction of soil aggregates (Horton 2019, Tamburini et al. 2016, Anderson and D'Souza 2014). Similarly, some reports demonstrated that conservation tillage (0–20cm) can improve soil fertility (Wang et al. 2019), maintain maize yield (Shao and Baumgartl 2016), and guarantee increased production (Ren et al. 2016). Deep tillage (above 25 cm) according to Mrabet (2011) enhanced significantly the number of grains per spike, 1000 grain weight of maize and the final grain yield by breaking hard bottoms (Ma et al. 2015), improving soil pore conditions, and increase permeability. These characteristics are needed for the distribution of plant roots in deep soils and the proper use of nutrients and water therein (Sun et al. 2013).

As important as varieties and cultivars are to crops' management and performances on the field, there are other factors aside from tillage practices that may be responsible for high crops' productivity on the field. Conservation tillage reduces damages of young plants from blowing sand (sandblasting) because it decreases the splash of soil onto plant parts during rainfall and it suppresses weeds' growth. As tillage does all these to crops, maize, being a fibrous root plant may not necessarily need deeper depth than 30 cm for its good performance. However, the effect of depth shallower than 30 cm on maize growth needs thorough investigation to check the nutrients' availability for plant growth, rate of yields obtained at varying depths of tillage and studying the correlation between depths of tillage and performances of different open-pollinated varieties of maize.

Materials and Methods

Experimental site

The field experiment was conducted at the Teaching and Research Farm of the College of Agriculture, Osun State University, (7.8717N 4.3067E) Ejigbo campus from April to August 2020. The climate was rain forest with bimodal rainfall between 1,158–1,250 mm per annum. The temperature regime is usually high all year round with a mean of 28–33°C, relative humidity of about 85%, except during the dry season with the sunshine of 5.1%. The climate of the area is characterized by pronounced wet and dry seasons, moderate temperatures in the wet season and relatively higher temperatures with moderate humidity during the dry season.

Land preparation, experimental layout and design

The experimental field was cleared manually to be sure of effective mechanical cultivation and to have desired soil depths of 0–15 cm and 0–30 cm. The dimension of the land was 73 m × 100 m. The land was divided into eighteen compartmental plots of 400 m^2 each comprising 2 depths of tillage (0–15 cm and 0–30 cm), 3 open-pollinated varieties (OPV 1, OPV 2, OPV 3), all at 3 replicates each to make 2 × 3 × 3 factorial design. The tillage treatments were laid out in randomized complete block design and replicated three times, Figure 1. Each plot measured 4 m × 10 m at 3 rows for each treatment was 4 m distance from the next (for passage of power tiller). Another headland of 10 m spacing from the entire areas of land, between experimental blocks was provided for power tiller passage and implement hitching process. The treatment consisted of the following tillage practices: ploughing as the first phase, ploughing followed by harrowing as the second phase. Both phases were within the procedural depths of tillage in the experiment and within two weeks intervals. At both stages, the ploughing depth and harrowing depth were within either the 0–15 cm or 0–30 cm tillage depths designed for the experiment. In all, the range of sowing depth of 6–10 cm was chosen as the depth of sowing in the experiment to have the highest plant height (BERHANU et al. 2016).

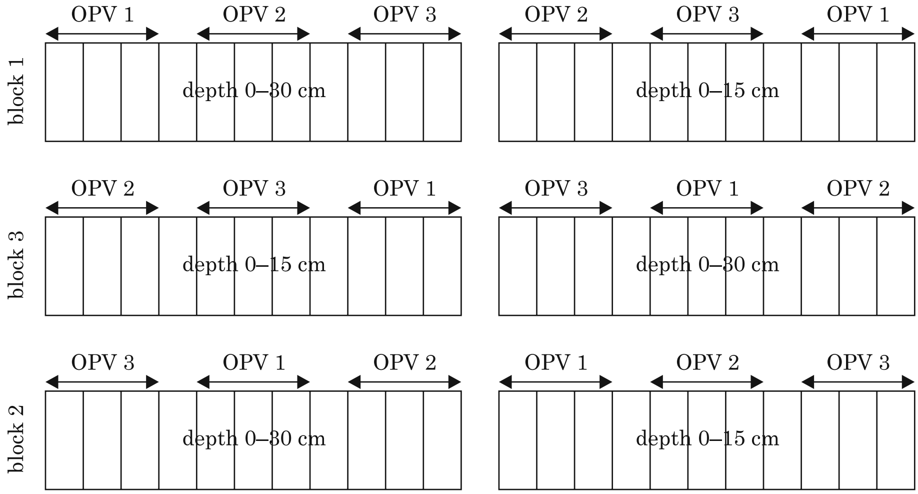

Fig. 1. Experimental layout of randomized compartmental plots

Configuration of disc plough to a depth of tillage desired

Power tiller, model name: Kubota PEM140 DI, 4-cycles, 10HP, 2400 rpm, made by Vikas Motor Co, India was used because it was easy to control the speed of the mechanical cultivation, and to be able to maintain the depths required according to the experimental procedures. Mounted disc plough, 3 furrows (Devta, made in India) were marked in the cylindrical jig, regarding their axes to synchronise with the precise 15 cm and 30 cm depths' marks required. These points were marked with yellow and red indelible paints at different points, yellow from the disc centre edge up on plough toward the disc circumference to make either 15 cm or 30 cm from the circumference where the 15 cm or 30 cm was painted red. There were two concentric circles in each disc, inner painted yellow, outer painted red at 15 cm or 30 cm, Figures 2a, 2b. The red point was always above the desired depth while the yellow was always the mark of the precise desired depth of tillage. The red marked line is on the outer disc to the edge. This was to minimize the influence of the roll angle during tillage operations along the elevation of the non-tillage road surface (KIM et al. 2020).

The power tiller was made to maintain a uniform speed of 5 km h^{-1} throughout the operation in each case as the plough was adjusted for the required depths in each situation. The low speed of the power tiller allowed the marked yellow-coloured spots and frame to be visible throughout the operation for both depths in all cases.

Soil samples were taken at a depth of 0–15 cm and 0–30 cm using random sampling techniques and analysed at the laboratory of the College of Agriculture of the Osun State University. The samples were mixed to form composites, air-dried and sieved using a 2 mm sieve.

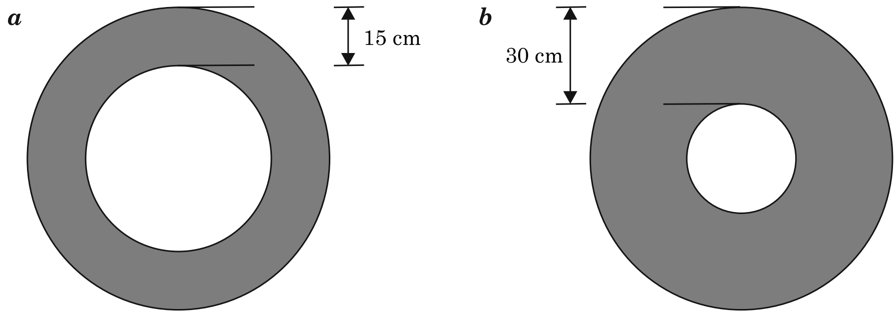

Fig. 2. Skech of plough at : *a* – 15 cm; *b* – 30 cm marked depth

Determination of growth parameters

The agronomic parameters collected include days to emergence of seeds, plant height (cm), number of leaves/plant, days to anthesis (DAT), days to silking (DAS), stem girth, Anthesis-Silking Interval (ASI), Leaf Area Index (LAI) and grain yield (GY) t ha^{-1} (EDMEADES et al. 2000).

Plant height [cm]: the heights of 10 randomly tagged plants were measured every two weeks from the ground level to the tip of the terminal leaf with the aid of a meter rule.

Number of leaves/plant: at least 20 representative plants were counted on after the milk stage

Days to anthesis (DAT): the plants in the three middle rows in each plot were used to estimate days to 50% tasseling. That is the number of days from sowing to when 50% of the plants have shed pollen.

Days to silking (DAS): the plants in the three middle rows in each plot were used to estimate days to 50% silking. That is the number of days from sowing to when silks have emerged on 50% of the plants

Stem girth: the girth (diameter) of the plant stem was taken weekly at the base of each plant about 5 cm above ground level with the aid of a vernier callipers. Ten (10) plants were randomly tagged from the fourth week to the tenth week for the girth data.

Anthesis-silking interval (ASI): this is measured as the differences between days to tasseling and days to silking.

Leaf area index (LAI): A quadrat of 2 m^2 area was selected randomly at 8 weeks after sowing where optimum plant growth was achieved from each plot. The measurement of length and width at the broadcast point of each leaf in the quadrat was then taken. Each leaf area designated as A was estimated by the formula:

$$A = L \cdot B \cdot 0.75$$

where:
L – the length of the leaf
B – the maximum width of the leaf [cm]
0.75 – the correction factor.

Grain yield (GY) t ha^{-1}. Grain Yield (kg ha^{-1} = (Ear weight (kg)/area in m^2).

Fertiliser application was not a factor in the research since an equal measured quantity of NPK 15: 15: 15 was used for the same plant in all the fields.

Statistical analysis

The data collected were subjected to analysis of variance (ANOVA), the means were separated using Duncan Multiple Range Test at a 5% level of significance.

Results

Maize yield components' performances at different tillage depths

The mean performance of three maize varieties at different tillage depths is represented in Table 1. There were no statistical differences ($p \leq 0.05$) in the values obtained for the days to 50% silking and days to 50% anthesis, but there were statistical differences for the length of leaves, LAI, stem girth and Anthesis-silking interval. OPV 3 had the highest number of leaves (11.33), Figure 3; plant height (144.78), stem girth 1.72 for 0–30 cm depth, Table 2 while OPV 2 had the highest mean value for leaf area index (8.97) and days to 50% anthesis (51.72).

Table 1

Mean values showing performances of three maize varieties

Varieties	LL [cm]	LAI [cm^2]	SG [cm]	DAT	DAS	ASI
OPV 1	87.75±0.71^b	8.90±0.37^a	1.54±0.08^b	51.39±0.24^a	56.17±0.41^a	4.78±0.75^a
OPV 2	97.17±0.75^a	8.97±0.41^a	1.64±0.06^a	51.72±0.27^a	55.39±0.46^a	3.67±0.11^{ab}
OPV 3	92.05±0.49^{ab}	8.68±0.13^b	1.65±0.07^a	51.56±0.48^a	55.44±0.43^a	3.89±0.15^b

^{ab} means on the same column with different superscripts are significantly different ($P < 0.05$).
LL – length of leaves; LAI – leaf area index; SG – stem girth; DAT – days to 50% anthesis; DAS – days to 50% silking; ASI – anthesis-silking interval

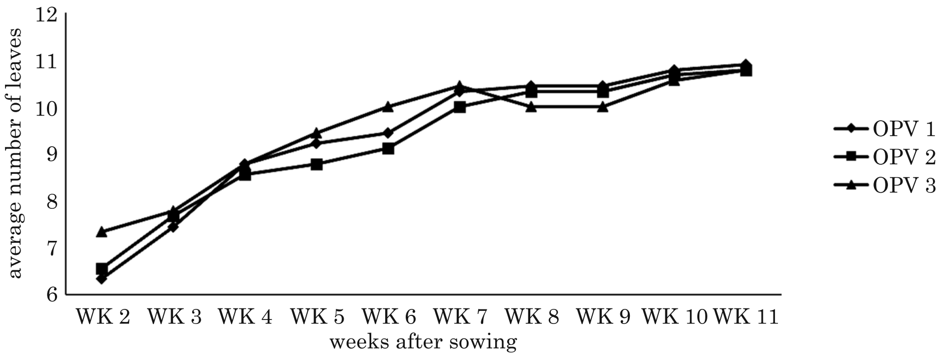

Fig. 3. Average weekly number of leaves per plant from OPVs at tillage depth of 0–15 cm

Table 2

Mean values showing different tillage depths on the performances of maize

Depth of tillage	LL [cm]	LAI [cm^2]	SG [cm]	DAT	DAS	ASI
0–15 cm	90.67±6.22^b	8.87±0.75^a	1.50±0.51^b	50.77±0.13^b	54.85±6.74^b	4.07±0.18^b
0–30 cm	93.98±5.49^a	8.82±0.81^b	1.72±0.14^a	52.33±0.15^a	56.48±7.10^a	4.14±0.21^a

^{ab} means on the same column with different superscripts are significantly different (P < 0.05). LL – length of leaves; LAI – leaf area index; SG – stem girth; DAT – days to 50% anthesis; DAS – days to 50% silking; ASI – anthesis-silking interval

The average number of leaves on selected marked maize stands among the replicates 1, 2, 3 and the varieties OPV 1, OPV 2 and OPV 3 are 9.41, 9.28 and 9.51 respectively for 0–15 cm depth and 9.96, 9.53 and 9.97 for 0–30 cm depth. In both depths, only OPV 1 and OPV 3 were statistically different from each other. From their standard deviation values depicted in Tables 1 and 2, they are closer to each other signifying lesser deviations in the values of the number of leaves. In Figures 3, 4, the number of leaves increased with an increase in number of weeks after sowing, as expected.

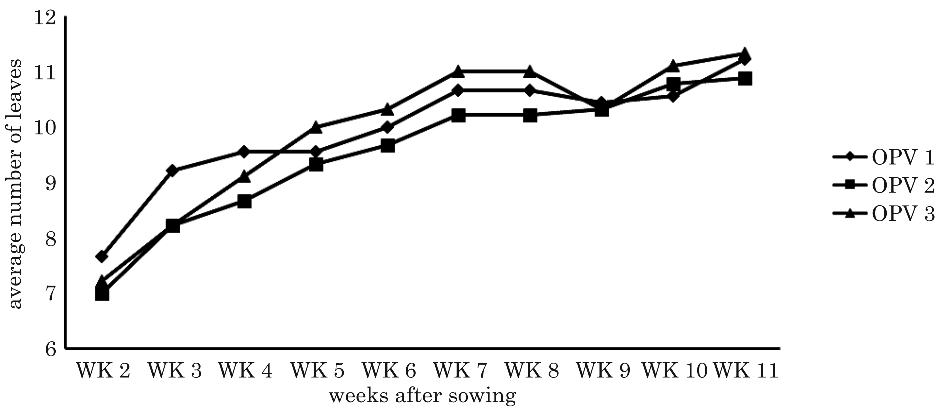

Fig. 4. Average weekly number of leaves per plant from OPVs at tillage depth of 0–30 cm

Also, there was constancy in the number of leaves starting from week 7, this happened in both depths, showing that healthy growth of tasseling has been initiated. However, the number of leaves were different for varieties OPV 1, OPV 2, OPV 3 at both depths of tillage.

On the mean values showing different tillage depths on the performance of the three maize varieties, Table 2 shows that the mean values of different tillage depths were statistically different for the length of leaves, leaf area index, stem girth, anthesis-silking interval and for all other yield components. The plant height, stem girth, days to 50% anthesis and days to 50% silking were all lower at 0–15 cm with 111.22, 1.50, 50.77 and 54.85 than corresponding values at 0–30 cm depth of tillage respectively, Tables 1, 2; Figures 5, 6.

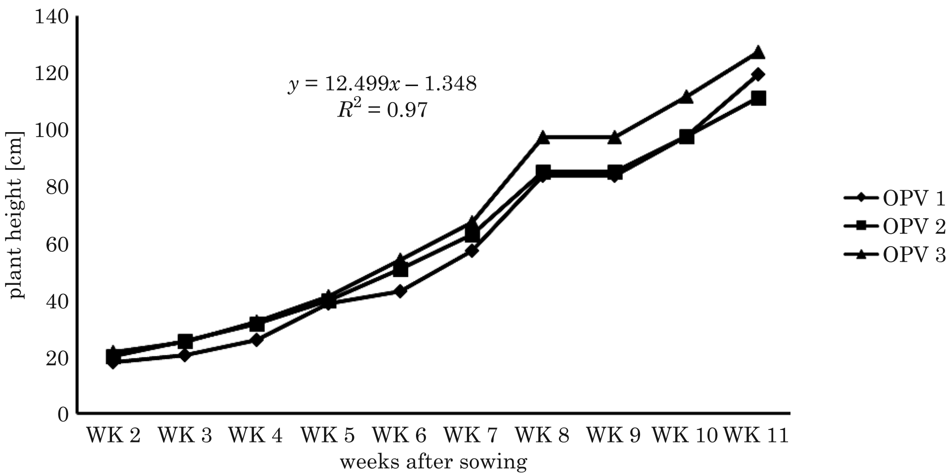

Fig. 5. Average heights of plants from OPVs at tillage depth of 0–15 cm

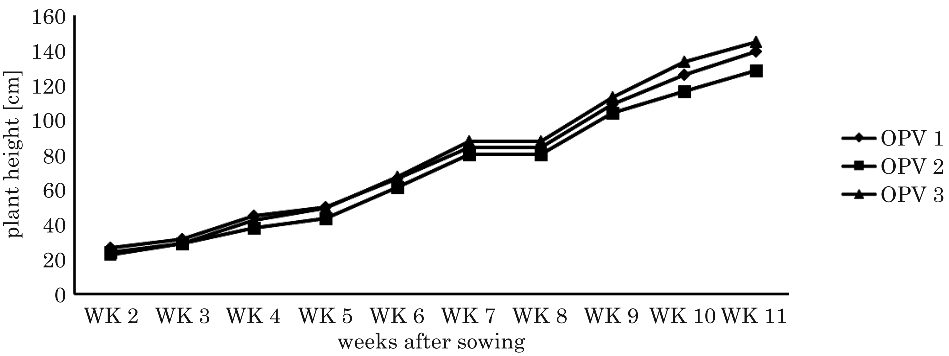

Fig. 6. Average heights of plants from OPVs at tillage depth of 0–30 cm

The yield of three maize varieties at different tillage depths

Table 3 shows the values of cob weights of the three post dehusking and pre dehusking maize varieties. It is of note that at both 0–15 cm and 0–30 cm depths of tillage, there were statistical differences among the mean values of the number of cobs and weights of cobs at the both before and after dehusking among different varieties OPV 1, OPV 2 and OPV 3. Similarly, there were statistical differences among the mean values of the harvested weights' recorded from cobs before and after dehusking among different varieties OPV 1, OPV 2 and OPV 3.

After dehusking cob weight was the highest at OPV 3 in 0–15 cm depth (8.67 and the lowest at OPV 2 (5.00). It is also worthy to note that varieties planted at 0–15 cm had the highest cob numbers and after dehusking cob weights than 0–30 cm depth. The three varieties have good morphological parameters that could have led to their moderate performances culminating in the highest yield of 9.90 t ha^{-1} recorded for the OPV 3 at 0–15 cm tillage depth. This was a 25.32% increase over the yield 7.90 t ha^{-1} recorded in the 0–30 cm depth of tillage.

Table 3

Cob weight yields of three maize varieties at different tillage depths

Tillage depth	Type	Variety	Mean	±SEM
0–15 cm	post-dehusking	OPV 1	6.77	0.34
		OPV 2	6.27	0.70
		OPV 3	8.67	1.70
	pre-dehusking	OPV 1	7.30	1.00
		OPV 2	7.33	2.03
		OPV 3	9.90	2.33
0–30 cm	post-dehusking	OPV 1	5.47	0.29
		OPV 2	5.00	0.58
		OPV 3	6.87	1.35
	pre-dehusking	OPV 1	5.83	1.15
		OPV 2	5.57	1.91
		OPV 3	7.90	2.23

Discussion

Yield components of different maize varieties at different depths of tillage

With OPV 3 having the highest number of leaves, plant height and stem girth, this may be as a result of genetic characteristics of the individual maize varieties. The findings of ENUJEKE (2013) agree with this, he reported that the variations in genetic constituents of the crops could lead to differences in growth indices of some crops as there could be physiological differences in their features. Values recorded for Anthesis-silking interval across all varieties indicated that they are modern and important for maize crop to be productive, for OPV 2 to have the value of anthesis-silking interval (3.67), although lower when compared to OPV 3 (3.89) which was 5.6% higher, both values could depict the fact that these two varieties have desirable genetic characteristics that can promote the much evidenced development in these yield components: number of leaves, plant height and stem girth in this open-pollinated variety provided they are adequately managed by the farmer. Also, these OPVs have the potentials of producing really high yields as evidenced in the values recorded especially for ASI across all the varieties. This is in line with the reports of ENUJEKE (2013) and MAGOROKOSHO et al. (2003). It can also be surmised that genetical variation for ASI may indicate differences in the relationship between other growth parameters (number of leaves, plant height, stem girth and LAI) and yield components (ASI, DAS, and DAT) and hence differences in partitioning of any could-be-formed of these growth parameters or yield components may assimilate to the crop's ear at flowering. It could also be attributed to the differences in yield components in maize cultivars to stomata conductance value and differences between genotypes in the partitioning of photosynthetic materials towards economic yield. (ENUJEKE 2013, MAGOROKOSHO et al. 2003, EDMEADES et al. 2000).

The highest number of leaves, plant height, leaf length and stem girth obtained for these maize varieties planted at the tillage depth of 0–30 cm agreed with the findings of ENUJEKE (2013) MRABET (2011) and MOLATUDI and MARIGA (2009). In contrast, WATO (2019), in his study reported that the shallower depth of planting for maize had the highest number of leaves, plant height, leaf length and stem girth than the deeper depth of planting. Although depths of planting are not the same as depths of tillage, though they are not independent of each other, therefore, the results of this experiment agreed with WATO (2019) findings on how depths of planting, depths of tillage affected the yield components in different maize varieties he experimented upon. Also, other factors like environmental parameters (not researched into in this study) may be responsible for differences in the yield parameters as revealed by these results, moreover, that depth of planting was within the depth of tillage 0–15 cm. The contrast on how shallower and deeper depths of planting affect performances of maize on the field may be a result of edaphic and environmental characteristics or genetic characteristics of the varieties used in this study. More investigations are needed to determine the effect of any of these factors on the yield components under tillage and planting.

Although 0–15 cm depth of tillage gave the highest yield of maize in the research, however WANG et al. (2019) reported that soil properties and crop yield improved when deep tillage of more than 25 cm was used in the North China Plain (which is a temperate area). This contrast may be so because of the differences between what temperate zone of the world may offer and what the tropical soil and environment may add to crops' growth and yield. In addition, tillage was also advantageous under water stress as the uptake of subsoil water and crop yield were increased. It could also be an observation related with the ability of tillage depth on the soil granular structure and also on the depth to which the root of the crop was restricted under shallow tillage and variations in the water and nutrient supply to the crop (PIAO et al. 2016).

Starting from week 7, there was apparent constancy in the number of leaves as more leaves were not added, this happened in both treatments. This shows healthy growth as tasseling should occur then. However, the number of leaves was different for varieties OPV 1, OPV 2, OPV 3 at both depths of tillage. This could be because of the differences in the depths of soil cut and the residual effects on the roots of maize which would allow their development in the soil to reach different depths due to factors like permeability, nutrients' ease of absorption and ease of soil aeration. This opinion agrees with PIAO et al. (2016).

The yield of different maize varieties at different depths of tillage

Maize varieties planted at 0–15 cm tillage depth had a better number of cobs than those planted at 0–30 cm, and out of the three varieties, at 0–15 cm OPV 1 had the highest mean number of cob while OPV 3 had the highest mean cob weight (9.90). These variations in yield may be the result of special genetic qualities possessed by the maize varieties. This opinion can be strengthened by the reports of SEID et al. (2013) and MOLATUDI and MARIGA (2009) who reported that some maize varieties have yield advantages over other maize hybrids due to their possession of special genetic qualities. These genetic qualities could have been therein in their cultivars and could have been intentional by the breeders or might have resulted from physiological processes within the seeds then or thereafter. The evident variations in yield of cob seen could also be related to tillage depth as 0–15 cm depth was better than 0–30 cm depth of tillage as shown in the 25.32% increase of OPV 3 in 0–15 cm depth over the yield, 7.90 t ha^{-1} recorded in the OPV 3 in 0–30 cm depth of tillage. The report corroborated WANG et al. (2019) and SHAO and BAUMGARTL (2016) who showed that conventional tillage increased maize yield.

Moreover, the statistical differences among the mean values of the harvested weights' recorded on cobs before and after dehusking among different varieties OPV 1, OPV 2 and OPV 3 could be due to some factors like variety differences, depths of tillage which could affect the development of roots and by extension affected shoot development in the maize as evidenced from the Figures 3–6 on the growth parameters namely the number of leaves and plants' heights. Also, these statistical differences among the yield components and growth parameters may be due to some other soil factors especially the soil biotic factors that were not taken into consideration as the experiment held them constant throughout for all the treatments in that period.

Conclusion

The study investigated the effect of different depths of tillage on the yield components of field tilled, sown with open-pollinated maize (*Zea mays* L.) varieties. Three varieties of open-pollinated varieties used in the research have good morphological performance but the highest yield was recorded at maize OPV 3. Also, maize varieties planted at 0–15 cm depth of tillage had better performance and yield than those planted at 0–30 cm depth of tillage. Depths of tillage and varieties have effect on the performances and yield of yellow maize on the field.

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