Ethiopian Journal of Environmental Studies & Management 14(2): 168 – 180, 2021.
ISSN:1998-0507 doi: https://ejesm.org/doi/v14i2.3
Submitted: December 24, 2020 Accepted: April 14, 2021

EFFECT OF DEPTHS OF TILLAGE ON SELECTED MORPHOLOGICAL CHARACTERISTICS, YIELD AND YIELD COMPONENTS OF YELLOW MAIZE (*Zea mays*) HYBRIDS

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Abstract
Ploughing and sowing depths may not only be responsible for good emergence of seed but could also be responsible for stronger stalk and stem girth, it is therefore necessary to investigate effect of depths of tillage on some yield and yield components of yellow maize (Zea mays) hybrids. The land was divided into eighteen compartmental plots of 400 m^2 each comprising 2 tillage depths (0-15 cm and 15-30 cm), 3 hybrids (HYB 2, HYB 4, HYB 6) at 3 replicates each to make 2×3×3 factorial design. Each plot measured 4 m × 10 m at 2 m apart from each other. The power tiller was made to maintain uniform speed throughout the operation in each case as the mouldboard ploughs were adjusted for the required depths. Among the data collected were days to emergence of seeds, plant height, number of leaves/plant, days to anthesis (DAT), days to silking (DAS), Anthesis-Silking Interval (ASI), Leaf Area Index (LAI) and grain yield (GY) yield/plant. Among the characters of selected maize association with anthesis to silking interval (0.32), 50% of anthesis (0.32) and also yield (0.33). Results showed that grain/yield depicted a highly significant position association with number of leaves (0.32), 50% tasselling (0.36) and 50% silking (0.33). Inter-character association revealed that anthesis to silking interval displayed highly significant association with days to silking (0.32) and also a highly significant negative association with 50% anthesis (-0.26). Yield had highly significant correlation with number of leaves, days to 50% tasseling, days to 50% silking. Inter-character association revealed that number of leaves had positive association with plant height and leaf area index.

Key Words: *Emergence of seed, Mouldboard Plough, Plant height, Power tiller, Stem girth*

Introduction

There is low productivity of maize in Nigeria. The average yield of maize in Nigeria is about 2.95 t/ha (CSA, 2012). This is by far below the world's average yield which is about 5.21 t/ha (FAO, 2011). Even now, this low productivity in maize has not change as Nigerian government has been importing maize from abroad for the past years. Likely factors responsible for low maize production in Nigeria are frequent occurrence of drought, declining of soil fertility, poor agronomic practices like inappropriate sowing depth, limited use of input, insufficient technology generation, lack of credit facilities, poor seed quality, diseases, insects, pests and weeds' problems (Afolabi *et al*., 2020). Tillage methods employed by farmers and depth of tillage and sowing may also be factors. Berhanu *et al.* (2016) revealed that sowing depth of 6 cm is the best depth of sowing to have the highest plant height and stronger stalk. Stronger stalk (stem girth) can lead to more yield per stand. Molatudi and Mariga (2009) also illustrated that sowing depth has significant effect on plant height at specified depth and recorded maximum plant height. The highest number of leaf was recorded at sowing depth of 6 cm, this sowing depth was the best sowing depth for more number of leaf per plant. In addition to this, the finding of (Seid *et al.,* 2013) also showed the same result.

The deepest sowing depth (10 cm) has a great effect on germination date, but in the shallowest sowing depth (2 cm), the sown seed accomplished its germination earlier than the other. This result is agreed with the finding of (Molatudi and Mariga, 2009) who stated that as the main requirement for germination is air, water and heat, the seed placed at near to the surface accomplishes their germination earlier than deepest one. Because of these sowing differences and the eventual effects on germination dates in maize, some other conditions like the tillage depths or nature of tillage may affect sowing depths (Kim *et al*., 2020).

Upon all these, if 6 – 10 cm depth of sowing was adjudged the best by some authors, definitely roots of crops will go deeper, likely for maize its fibrous roots may be more than 15 cm deeper in the soil. Thus the depth of tillage 0-15 cm may have to be supplemented by other deeper depth, therefore the choice of 15-30 cm depth of tillage for maize cultivation was conceived in the research. Both depths of tillage and nature of tillage may not only be responsible for emergence of seed but could also be responsible for stronger stalk and stem girth, it is therefore necessary to investigate effect of depths of tillage on some yield and yield components of yellow maize (*Zea mays*) hybrids. The objective of the study was to evaluate different depths of tillage on selected morphological characteristics, yield and yield components of yellow maize (*Z. mays*) hybrids.

Materials and Methods

Experimental Site

The field experiment was conducted at the teaching and research farm of the College of Agriculture, Osun State University, (Latitude 7° 52′ N; Longitude 4° 18′ E) Ejigbo campus from April to July, 2020. The climate is typically rain forest with two peaks of rain (bimodal rainfall) which is between 1,158mm-1,250 mm per annum. The temperature regime is usually high all year round with mean of 28 - 33°C, relative humidity of about 85%, except during dry season with sunshine of 5.1%. The climate of the area is characterized by pronounced wet and dry seasons, moderate temperatures during the wet season and relatively higher temperatures during the dry season.

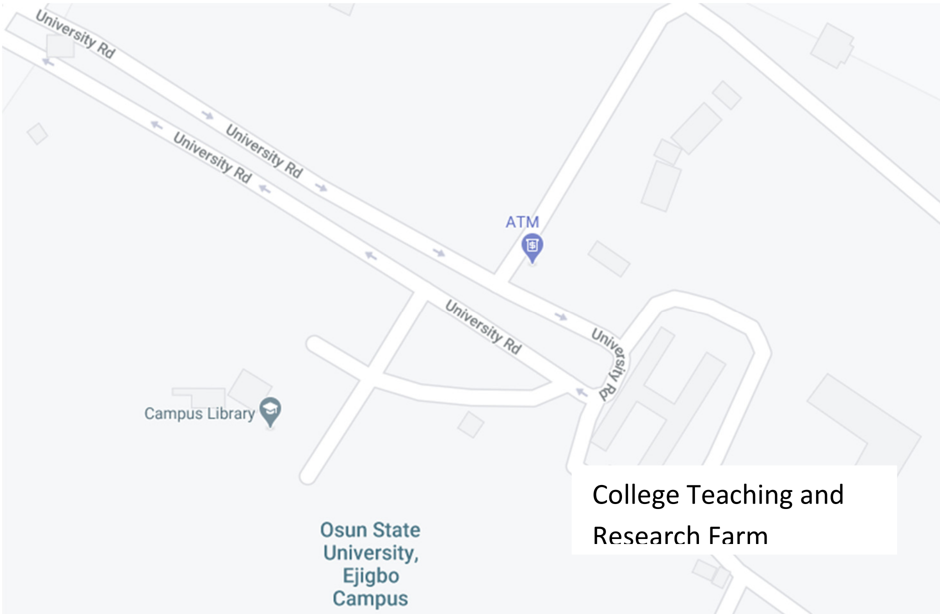

Fig. 1: Map showing College Teaching and Research Farm – the site of the experiment

Land preparation, Experimental Layout and Design

The experimental field was cleared manually to be sure of effective tractorisation and desired soil depths of 0-15 cm and 15-30 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 15-30 cm), 3 hybrids (HYB 2, HYB 4, HYB 6), all at 3 replicates each to make 2×3×3 factorial design. Each plot measured 4 m × 10 m at 2 m apart from each other. A headland of 10 m spacing from the entire areas of land was provided for power tiller/tractor passage and implement hitching process. The treatment consisted of the following tillage practices: ploughing as first stage and ploughing with harrowing as second stage. Both stages were within the procedures of the experiment and within two weeks intervals. At both stages, the ploughing depth and harrowing depth were within either the 0-15 cm or 15-30 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).

Configuration of Mouldboard Plough to Depth of Tillage Desired

Power tiller was used. It was easy to control the speed of the tractorisation, and to be able to maintain the depths required according to the experimental procedures. The mouldboard ploughs were marked in the cylindrical jig, with reference to their axes to synchronise with the 15 cm and 30 cm depths required. These points were marked with yellow and red indelible paints at different points, yellow from one diameter edge up on plough toward the cylindrical centre to 15 cm / or 30 cm and other half sector of circle with red. The red point was always above the desired depth while the yellow was always the precise depth of tillage required, just at the red marked line is on outer mouldboard frame. This was to minimize the influence of the roll angle during tillage operations along the elevation of the non-tillage road surface.

The power tiller was made to maintain uniform speed of 5km/h throughout the operation in each case as the mouldboard ploughs were adjusted for the required depths in each situation. The low speed of the tiller allowed the marked yellow spots and frame to be visible throughout the operation for both depths in all cases. The tillage treatments were laid out in randomized complete block design and replicated three times.

Soil samples were taken at a depth of 0-15cm and 15-30 cm using random sampling techniques and analysed at the University Agronomy Laboratory. The samples were mixed to form composites, air dried and sieved using 2 mm sieve. Physical and chemical properties are shown in Table 1. Among the data collected were days to emergence of seeds, plant height, number of leaves/plant, days to anthesis (DAT), days to silking (DAS), Anthesis-Silking Interval (ASI), Leaf Area Index (LAI) and grain yield (GY) per ha.

Statistical Analysis

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

Results and Discussion

Physico-chemical Properties of the Experimental Site

The phvsico-chemical properties of the study area are shown in Table 1. The soil was predominantly sandy loam. The surface had more sand than the subsurface. The soil is neutral with a pH of 6.4 which was good for maize. The organic matter and total nitrogen content were low with values of 0.52% and 0.04 gkg^{-1}, respectively. The available P was equally low with a value of 1.07 mg/kg. The exchangeable cations were low in status with values of 2 $cmolkg^{-1}$ for Ca and 0.09 $crnolkg^{-1}$ for Mg. The values obtained for K (1.22 $cmolkg^{-1}$) was low. This could be attributed to low activity of the micro-organism in the area while the low values obtained for organic C, total Nitrogen and P were as a result of erosion that is predominant in the area and subsequent leaching of the nutrient beyond the root zone. These soil conditions will not allow the maize to grow well except if low nitrogen maize is planted and the hybrids were just so.

Variation in Morphological and Growth Parameters

The analysis of variance for the characters of the three yellow maize hybrids evaluated for yield potential is shown in Table 2. The depth of tillage depicted a highly significant variation for leaf area index (2267.91), days to 50% tasselling (35.54), days to 50% silking (33.13), and yield/plant (0.05). At hybrid level, only stem girth (0.13) showed significant variation. Furthermore, the interaction between depths and hybrids depicted highly significance for plant height (56.42), days to 50% tasselling (27.63), days to 50% silking (38.17), yield/plant (0.01). In all, the coefficient of variation values were as low as 0.14, 0.67 and all were below 25 except for DAS (days to 50% silking), thus they were all within acceptable range.

The statistical differences observed in different hybrids via morphological traits in the growth rates in maize especially in the stem girth indicated variations among maize hybrids and depths of tillage, this may show that hybrids genetically differ for these particular characters. Also, highly statistical differences in depth of tillage observed via leaf area index, number of leaf, days to 50% anthesis, days to 50% silking and yield per plant could be surmised to be as a result of genetical differences for these particular characters. Similar conclusion was made by Aikins *et al.* (2011) who studied effect of four different sowing depths on soybean growth and dry matter yield and reported highly significant differences for number of leaves per plant, it implies that these characters can be used for maize yield improvement.

Furthermore, statistical differences revealed in the interaction between various hybrids and depths of tillage could be because of other factors that may include environment and possible changes in the expression of character. The fact that coefficient of variation ranged from 0.67 stem girth to 25.02 days to 50% silking indicated that the experimental design employed was appropriate and adequate for this experiment. Table 2 showed statistical differences among the growth and yield components for the maize under different depths of tillage and hybrids. These observations could be attributed to different morphological variations in the hybrids used and probably also on the depth of tillage or could also be on how far the fibrous roots of maize could have reached down in the soil due to different tillage depths.

Mean Performance of Three Yellow Maize Hybrids

The growth performance and mean yield of the three yellow maize hybrids is displayed in Table 3. HYB 6 had the earliest days to emergence (3.44) which was not significantly different from HYB 4 (3.50) and HYB 2 (3.63), Table 2. In addition, plant height revealed that HYB 2 (80.49) had the tallest height compared to HYB 4 (79.41) while HYB 6 had the shortest height (79.26) with no significant difference among them. Similarly, leaf area index as displayed in Table 2. HYB 4 had the highest leaf area index (2200.39) which was different in magnitude from HYB 2 (2120.27) and HYB 6 (2188.08).

There were statistical differences among the hybrids with relation to depth of tillage in some growth parameters namely LAI, stem girth and ASI and also in the yield, Table 3. Similarly, there were statistical differences between the different depths of tillage in all the growth parameters except days to emergence and so there was statistical difference between the yield, Table 3. Moreover, HYB 4 displayed the fattest stem (0.69) with a significant difference from HYB 6 (0.60) and HYB 2 (0.52). In addition, days to 50% anthesis revealed that HYB 2 had the shortest days (51.21) with no significant difference from HYB 4 (51.28) and HYB 6 (52.17). Similarly, for days to 50% silking, HYB 2 records the shortest day to silking (55.26) with no significant difference from HYB 4 (55.78) and HYB 6 (55.89). However, HYB 6 displayed the shortest anthesis to silking interval (3.72) with a significant difference from HYB 4 (3.89) and HYB 2 (4.63). HYB 4 displayed the highest yield (0.14) compared to HYB 2 (0.10) and HYB 6 (0.12), also with significant difference among them. Those differences could also be as a result of soil conditions that was manipulated in tillage, this could be a possibility since they were all subjected to the same climatic conditions and other management handlings.

Effect of Two Depths of Tillage on Selected Morphological Traits of Yellow Maize Hybrids

The effect of different depths of tillage on selected morphological characteristics of *Zea mays* hybrids given showed significant difference among several characters, depth of 15-30 cm gave the highest value for plant height, number of leaf, stem girth, days to 50% tasselling, days to 50% silking with 81.83±0.18, 15.59±0.84, 0.66±3.16, 52.37±0.18 and 56.41±9.13 respectively (Figures 2 and 3). The 0-15 cm depth recorded the highest value for days to emergence (3.57±0.18), leaf area index (84.78±6.28) and yield (0.96±0.43). Furthermore, there were statistical differences in the hybrids among the morphological traits like leaf area index, number of leaf, days to 50% tasselling, days to 50% silking, anthesis-silking interval, and yield, Table 3.

HYB 6 of all the three hybrids of maize used could boast shortest days (3.72) for Anthesis-Silking Interval (ASI), followed by HYB 4 (3.89) which in turn shows that if properly managed could give a higher yield. This observation was in line with Magorokosho *et al.* (2003). The similar growth with respect to plant height observed among the hybrids may be attributed to similarities in genetic characteristics of the individual hybrids, including rapid growth rates, tallness or shortness of species. This is similar to the findings of Enujeke (2013) that attributed the differences in growth indices of crops to genetic constituent. The superiority of HYB 4 over hybrids with respect to stem girth may be attributed to special qualities credited to early maturity, uniformity in flowering and ear-placement, and very high yield. Some maize hybrids may have yield advantage over other maize hybrids due to their possession of special qualities like high disease resistance, early maturity, uniformity in flowering and ear placement, and ease of harvesting using combine harvester.

Furthermore, there were differences observed in leaf area indices of the hybrids of maize, this can be attributed to the dissimilarities in leaf arrangement, photosynthetic activities of leaves, differences in number of leaves resulting in chlorophyll content and activity of photosynthetic enzymes. This could also be attributed to the differences between the leaf area and other growth parameters of maize genotypes to differences in photosynthetic activity of leaves, leaf arrangement, chlorophyll content, stomatal conductance value and activity of photosynthetic enzymes.

The maximum number of leaf was recorded with planting depth of 15-30cm. This may implies that as depth of tillage and sowing seed increases, the number of leaves increases. This findings was in agreement with Tamirat (2019) who observed that the lowest number of leaves were recorded with a depth of 20 cm. However, Molatudi and Mariga (2009) depicted that 15cm planting depths had significant contribution to number of leaves. This could influence the ultimate plant stand as the crop matures and also make plant stem withstand lodging. Depth of 0-15cm had the earliest days to tasselling and days to silking indicating that tillage depth influences the germination and emergence of seedling (Ghaderi-far *et al.,* 2010). Similarly, grain yield per plant increased with sowing up between 0-15cm, this result was in line with the observation of Mehmet and Digdem (2009) who studied the effects of four different sowing depths on grain yield and some grain yield components in wheat, where he concluded that sowing above 9 cm depth is thought that roots of plants at below 0-15 cm (that is between 15-30 cm) sought out moisture deeper in the soil profile because the top soil layer is assumed to have dried out very quickly.

Table 1. Physical and Chemical properties of the soil

PARAMETERS	VALUE
Chemical Properties	
pH (H_2O)	6.40
Organic carbon (%)	0.52
Total Nitrogen (g/kg)	0.041
Available Phosphorus (mg/kg)	1.07
Na^+(cmol/kg)	0.18
K^+(cmol/kg)	1.22
Ca^{2+}(cmol/kg)	2
Mg^{2+}(cmol/kg)	0.09
Bulk density (g/cm^3)	1.2
Physical Properties of Soil (%)	
Sand	69.1
Silt	15.5
Clay	15.4

Ca = Calcium, Mg = Magnesium, K = Potassium, Na = Sodium

Table 2: Analysis of variance of three selected yellow maize hybrids planted at different tillage depth

SOV	DF	DEM	PH, cm	LAI, cm^2	No. of leaf	Stem girth,cm	DAT	DAS	ASI	YIELD, kg
Depth	1	0.09^{ns}	53.46^{ns}	2267.92^{**}	30.05^{**}	0.12^{ns}	35.54^{**}	33.13^{**}	0.04^{ns}	0.05^{**}
Hybrids	2	0.02^{ns}	93.12^{ns}	1762.42^{ns}	0.53^{ns}	0.13^{*}	3.59^{ns}	1.19^{ns}	3.89^{ns}	0.01^{ns}
Depth× Hybrids.	2	0.28^{ns}	56.42^{**}	2443.08^{ns}	0.08^{ns}	0.09^{ns}	27.63^{**}	38.17^{ns}	0.85^{ns}	0.01^{*}
Error	37	0.71	1.33	25.06	0.16	0.03	0.21	0.19	0.18	0.01
CV%		3.67	22.37	11.91	15.18	0.67	21.98	26.03	4.39	0.14

*= significant at p≤0.05, **=highly significant at p≤0.01, CV%=Coefficient of Variation, SOV= Sources of Variation, DF=Degree of Freedom, DEM=Days to emergence, DAT=Days to 50% Anthesis, DAS=Days to 50% Silking, ASI=Anthesis-Silking Interval, LAI=Leaf Area Index, PH= Plant Height, Yld/plt= Grain Yield per plant

Table 3: Mean Performance of three yellow maize Hybrids

Hybrids	DEM	PH., cm	LAI, cm^2	No. of Leaf	Stem Girth, cm	DAT	DAS	ASI	Yield, kg
HYB 2	3.63 ± 0.03^{a}	80.94 ± 2.73^{a}	2120.27 ± 0.68^{a}	15.31 ± 0.39^{a}	0.52 ± 0.09^{b}	51.21 ± 0.29^{a}	55.26 ± 0.46^{a}	4.63 ± 0.74^{a}	0.10 ± 0.09^{a}
HYB 4	3.50 ± 0.06^{a}	79.41 ± 2.71^{a}	2200.39 ± 0.72^{a}	14.5 ± 0.40^{a}	0.69 ± 0.08^{a}	51.28 ± 0.28^{a}	55.78 ± 0.44^{a}	3.89 ± 0.12^{a}	0.14 ± 0.01^{a}
HYB 6	3.44 ± 0.05^{a}	79.27 ± 1.81^{a}	2188.08 ± 0.45^{a}	14.72 ± 0.11^{a}	0.60 ± 0.09^{ab}	52.17 ± 0.50^{a}	55.89 ± 0.49^{a}	3.72 ± 0.17^{b}	0.12 ± 0.02^{a}

^{ab}= means on the same row with different superscripts are significantly different. (P<0.05). DEM=Days to emergence, PH= Plant Height, DAT=Days to 50% Anthesis, DAS=Days to 50% Silking, ASI=Anthesis-Silking Interval, LAI=Leaf Area Index, and GY/plt= Grain Yield per plant

Correlation between Grain Yield and Other Essential Traits of the Maize Hybrids

Association among the characters of selected maize hybrids grown is given in Table 5. According to the results, grain/yield depicted a highly significant position association with number of leaf (0.32), 50% tasselling (0.36) and 50% silking (0.33). Inter-character association revealed that anthesis to silking interval displayed highly significant association with days to silking (0.32) and also a highly significant negative association with 50% anthesis (-0.26). Among the characters of selected maize association with anthesis to silking interval (0.32), 50% of anthesis (0.32) and also yield (0.33). In addition, days to 50% silking displayed a positive significant with number of leaf (0.29).

The significant differences and positive association among grain yield, number of leaves, days to tasselling, days to 50% silking implied that the selection of these characters could simultaneously increasing grain yield, thus, it could be utilized in direct selection program. Similar finding to this study was reported by Begum *et al*. (2016) who reported that inter-character associations for yield components revealed positive and highly significant association of days to 50% tasselling with days to silking, plant height and ear height. The result is also supported by Nataraj *et al*. (2014). The significant negative correlation between two characters which anthesis to silking interval and days to 50% anthesis indicates that such characters can be improved simultaneously in a selection programme due to the strong relationship between both characters (Eleweanya *et al*., 2015). In addition, the positive and highly significant correlation between anthesis to silking interval and days to 50% silking shows that their influence on grain yields (tha^{-1}).

Furthermore, inter-character association revealed that days to anthesis had highly significant positive association with number of leaf (0.32), days to silking (0.86), anthesis-silking interval (0.32) and yield (0.33). It also had positive significant correlation with 50% tassselling (0.29). In addition, leaf area index a highly significant correlation with number of leaf (0.33). Finally, plant height showed highly significant association with number of leaves (0.31).

The highly positive correlation among number of leaf, days to 50% silking and yield harvested suggests that these characters are controlled by the same gene, indicating that the selection of one character automatically leads to the selection of the other. The positive highly significant association between plant height and number of leaves shows among the traits other than grain yield per plot which might aid understanding of idea of plant type. Similar observations were reported by Jakhar *et al*. (2017). Therefore, the positive highly significant correlation among number of leaf, leaf area index, and plant height was in harmony with findings of Wannows *et al*. (2010) who found significant correlation between leaf area index and number of leaf.

Table 4: Mean values showing effects of different depths of tillage on growth parameters in maize

Depths	DEM	PH, cm	LAI, cm^2	No. of Leaf	Stem Girth, cm	DAT	DAS	ASI	Yield, kg
0-15	3.57±0.18[a]	77.73±4.14[b]	2284.78±6.28[a]	14.14±0.78[b]	0.56±2.80[b]	50.75±0.18[b]	54.26±6.78[a]	4.14±1.08[a]	0.96±0.43[a]
15-30	3.48±1.16[a]	81.83±4.18[a]	2221.26±5.58[b]	15.59±0.84[a]	0.66±3.16[a]	52.37±0.18[a]	56.41±7.13[b]	4.04±0.98[b]	0.16±0.18[b]

[ab]= means on the same row with different superscripts are significantly different. ($P<0.05$). DEM=Days to emergence, PH= Plant Height, DAT=Days to 50% Anthesis, DAS=Days to 50% Silking, ASI=Anthesis-Silking Interval, LAI=Leaf Area Index, and GY/plt= Grain Yield per plant

Table 5: Correlation matrix of the variables used in the PC of three maize genotypes and two different sowing depths evaluated

	DEM	Plt Hgt.	LAI	No. of Leaf	Stem Girth	DAT	DAS	ASI	Yield.
DEM	1	0.11[ns]	0.163[ns]	0.197[ns]	0.07[ns]	0.25[ns]	0.16[ns]	0.15[ns]	-0.05[ns]
Plt Hgt.		1	0.72[ns]	0.31**	-0.04[ns]	-0.07[ns]	-0.16[ns]	0.15[ns]	-1.17[ns]
LAI			1	0.33**	0.06[ns]	-0.07[ns]	0.11[ns]	-1.47[ns]	-0.05[ns]
No. Leaf				1	0.05[ns]	0.32**	0.29*	0.60[ns]	0.32**
Stem Girth					1	0.21[ns]	0.12[ns]	0.17[ns]	-1.29[ns]
DAT						1	0.84**	-0.26**	0.36**
DAS							1	0.32**	0.33**
ASI								1	-0.40[ns]
Yield									1

*= significant at $p\leq0.05$, **=highly significant at $p\leq0.01$, DEM=Days to emergence, DAT=Days to 50% Anthesis, DAS=Days to 50% Silking, ASI=Anthesis-Silking Interval, LAI=Leaf Area Index, and GY/plt= Grain Yield per plant

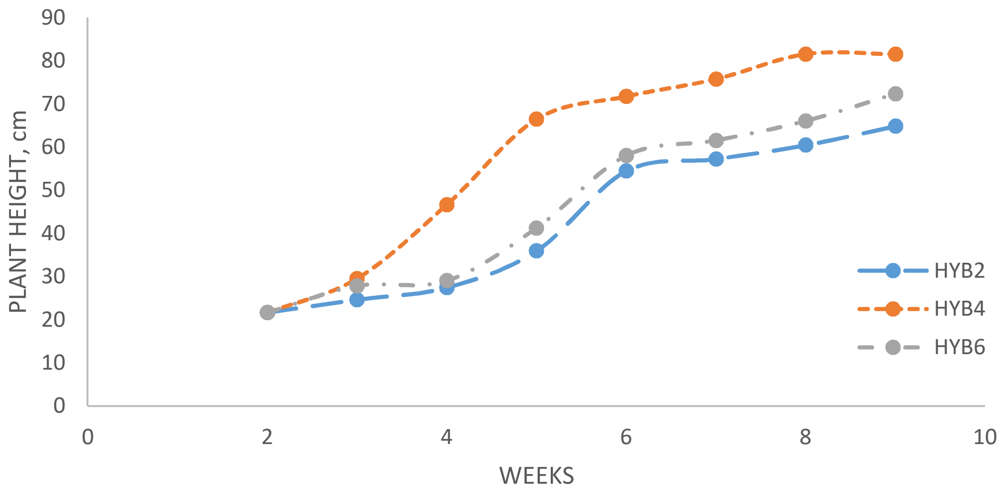

Fig. 2: The graphical representation of maize plant height of three types of Maize hybrids at 0-15cm depth

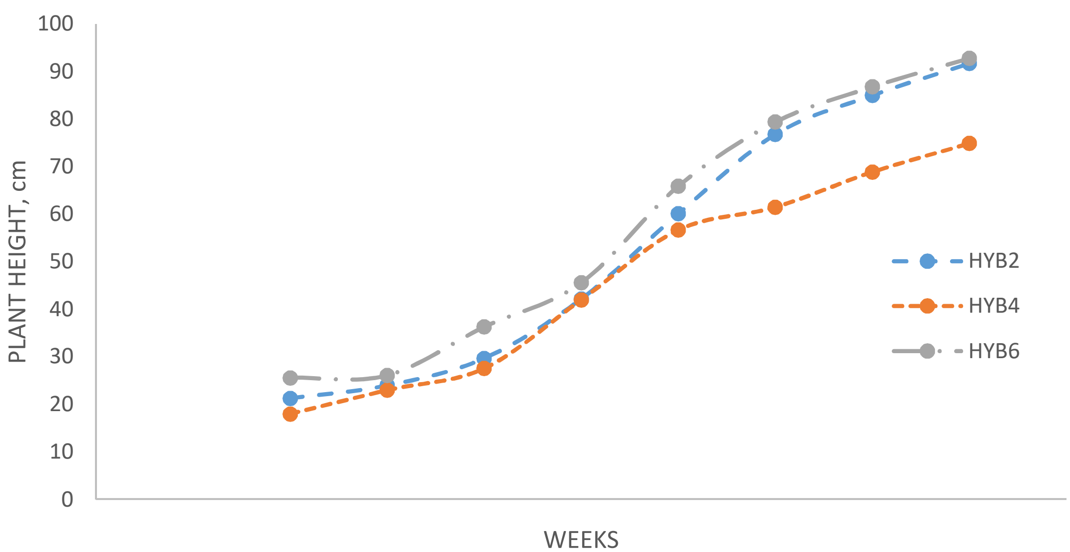

Fig. 3: The graphical representation of maize plant height of three types of Maize hybrids at 15- 30cm depth

Conclusion

Highest yield was recorded for HYB 6 and HYB 4 (being the highest) while the lowest was found in HYB 2 and at depth 0-15 cm. Yield had highly significant correlation with number of leaf, days to 50% tasseling, days to 50% silking. Inter-character association revealed that number of leaf had positive association with plant height and leaf area index.

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