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# THE PERFORMANCE OF SEVEN ELITE MAIZE ACCESSIONS FROM DIFFERENT AFRICAN ORIGINS UNDER RAIN-FED CONDITIONS IN SOUTH-EASTERN NIGERIA

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## ABSTRACT

Maize is an important cereal crop, and millions of Africans rely on it as a major source of carbohydrates in their diet. Grain yield from local maize varieties is generally low. Evaluation of different maize genotypes within a specific region is one way to identify and introduce varieties with high yield potential. This study assessed the yield and agronomic traits of 6 exotic maize accessions and a local variety to compare the performance of the exotic accessions with the local variety. The experiment was laid out as a randomized complete block design with four replications. The treatments included six exotic maize accessions, *TZM386, TZM85, TZM16, TZM109, TZM392, and TZM1330,* and a local variety '*Uwep'* the result indicated that there were no significant differences in plant height and plant population at anthesis. Grain yiel among all accessions was not greater than 0.5 t/ha in 2020 but ranged between 1-3 t/ha in 2021. There were no significant differences in grain yield and components between the exotic and local accessions in 2021. In 2020, TZM 386 outperformed the local variety (uwep) in grain yield, ear weight, and number of ears/ha. Multiple linear regression showed a high dependence of grain yield on the growth parameter-plant height and the yield component ear no/ha in 2020 and 2021. This study has revealed differences in yield traits between the local and exotic accessions. The maize accession TZM 386 showed potential for higher grain yield and yield components and appears to be a promising candidate for further research.

## INTRODUCTION

Maize (*Zea mays L.*) is the third most important cereal crop after wheat and rice in Nigeria. It is a primary source of carbohydrates for many families, and it adds significantly to the incomes of small-scale farmers annually. About 45.5% of maize produced in Nigeria is used to manufacture animal feed, about 6.5% is used in the brewing industry, and some 13% is used in the production of flour (PWC 2021; Langyan *et al*., 2022). Maize is produced in most parts of the country but the bulk comes from the northern states (Anonymous 1987). One challenge with maize production is low grain yield; local maize yields below 2 t/ha on average, depending on the soil and environmental conditions (Ullah et al. 2018; Efretuei and Udounang 2020). The reasons for low yield include lack of access to or an insufficient number of region-targeted improved varieties, expensive fertilizers and pesticides, poor dissemination of good agricultural practices, and insect pests such as stem borers.

Evaluation of different maize genotypes within a specific region is one way to identify and introduce varieties with high yield potential (Rahimi Jahangirlou *et al*., 2021). Okoji and Nworji (2020) adopted this approach when they evaluated 21 maize genotypes for yield and other agronomic traits in south-eastern Owerri and observed variation between maize genotypes. They recommended the highest-yielding genotype OKA BENDE-WHITE (which produced 2.86 t/ha) for use in future breeding programs. Similarly, a study further down south to compare the performance of exotic maize accessions (origin from similar ecological zones in Africa) with a local variety in Nigeria revealed 4 of the exotic accessions TZm-299, TZm-109, TZm-1553, and TZm-378, outperformed the local variety in yield and agronomic traits (Edet Obok et al., 2021).

The knowledge of genetic and phenotypic variability is helpful in the production of high-yielding maize varieties The genetic and phenotypic variation is influenced by the environment. Therefore, it is advantageous to know the environmental and agronomic responses of maize varieties within a specific location; this would guide the decisions on what varieties to recommend to a specific region. Furthermore, it would be beneficial to have more knowledge on what proportion an agronomic trait contributes to grain yield.

A change in agronomic trait invariably affects grain yield; an analysis by Ren *et al.* (2022) over a 10 year maize study revealed agronomic traits accounted for 54% of yield variation while changes in climate factors accounted for 26% yield variation. More recently, in a Nigerian study, Adewumi et al (2023) studied the agronomic performance of 14 maize hybrids and concluded that grain yield and plant height were positively correlated implying that plant height is an important contributor to grain yield.

Some listed agronomic traits of relevance in maize production include: plant height, ear height, weed and disease resistance, resistance to stem lodging and high and stable yield, double ear rate, ear length, ear rows, line grain number, grain number per ear, ear diameter, cob diameter, and 1000 grains weight (Abadassi, 2015; Ren et al.,2022). These traits identified can assist in selecting superior parents for high grain yields. .

This study, compared the yield and agronomic traits of 6 exotic maize accessions and a local variety to compare the performance of the exotic accessions with the local variety; to determine the most appropriate for optimum yield in the study area, and recommend the accession for inclusion in a breeding program.

## MATERIALS AND METHODS

### The experimental site, design and treatments

The field experiment was conducted in the early planting season (April – July) of 2020 and 2021. The study was sited at the Teaching and Research Farm of the Akwa Ibom State University, Obio Akpa Campus in Oruk Anam Local Government Area, Akwa Ibom State. The experiment was laid out as a randomized complete block design having four replications and 7 treatments. The treatments included six exotic maize accessions, *TZM386, TZM85, TZM16, TZM109, TZM392, and TZM1330,* supplied by the Genetic Resource Center, IITA Ibadan, Nigeria, and a local accession '*Uwep'* commonly cultivated in Akwa Ibom State (table 2.1). The experimental area measured 29 x 17 m, making a total 493 $m^2$. Each treatment plot measured 3 x 3 m.

### Land preparation and planting materials

A composite soil sample at a depth of 0-15cm was collected with a soil auger (in 2020) to determine the physical and chemical properties of the soil. Poultry manure was applied to the entire field experiment 4 days before planting at the rate of 2 t/ha to boost the fertility status of the soil. NPK fertilizer (15:15:15) was applied at 400 kg/ha in two equal splits using the band application method (which is translated into 60 kgN/ha, 60kgP/ha, and 60KgK/ha). The first split of application was applied two weeks after planting, and the second split was applied six weeks after planting. This was applied according to recommended standard for most maize varieties. Weeding was done manually and twice at four weeks and lastly at eight weeks after planting. The major pests found in the field were the stem borers and armyworms; these were controlled using Hallakat pesticide, which is a combination of two active ingredients (Emamectin benzoate and Acetamiprid) at the rate of 250 ml/ha. The pesticide was applied at four weeks, six weeks, and eight weeks after planting.

### Data collection and analysis

During anthesis, the plant height (cm), the total number of lodged plants, and the total plant population were recorded. At maturity, yield parameters measured for each treatment were ear length, ear number/ha, ear weight (with/without the husk)/ha, and grain yield kg/ha.

Data collected were analyzed using a one-way analysis of variance on IBM SPSS Statistical Software Version 22. Statistical significance was determined at the P<0.05 probability level. Where there were significant differences between means, the differences were separated using the Tukey-Kramer Multiple Comparison Test. A simple linear regression on R Studio Software was used to determine the relationship between grain yield and growth parameters across all varieties.

**Table 2.1 Description of the Various Maize Accessions**

| Accessions | Description |
|---|---|
| **Uwep** | Uwep is an open-pollinated white maize seed mostly used in Akwa Ibom State and the South-South region of Nigeria to prepare porridge. |
| **TZM-16** | Originates from Tanzania. The other name is Katumani. Stores for long. The number of days from planting to 50% flowering is 48, and plant height is 228 cm, and it takes 98 days to harvest time; grain colour is yellowish white. |
| **TZM-85** | Originates from Zimbabwe. The number of days from planting to 50% flowering is 52; it takes 115 days from planting to harvest time and can reach a plant height of 168 cm; grain color is white |
| **TZM-109** | Originates from Benin. Takes 51 days from planting to 50% flowering and 100 days from planting to 50% harvesting; it can reach a height of 214 cm, and the grain colour is orange. |
| **TZM-386** | Originates from Congo. Takes 51 days to 50% flowering and 102 days from planting to harvesting. Plant height of 1104cm, grain color is white. |
| **TZM-392** | Originally from Congo. It takes 57 days to 50% flowering and 102 days from planting to harvesting. The grain color is blue-black. It can reach a height of 201cm. |
| **TZM-1330** | Originates from Togo. The grain color is white. It reaches a height of 290cm, it takes 55 days to 50% flowering, 96 days from planting to harvesting |

**Source: https://www.iita.org/research/genetic-resources/**

## RESULTS AND DISCUSSION

### Soil Physical and Chemical Properties

Table 3.1 shows the physical and chemical properties of the soil in the study area for 2020**. In 2020,** the soil in the experimental site had a loamy texture. The soil was moderately acidic (pH 4.7), which is typical of soils in the rainforest region of Nigeria and of previously reported studies in this study site (Ekwere et al., 2021; Efretuei et al., 2023). The mean total nitrogen (N) was 0.05% which is low compared to typical N levels for this ecological zone ranging between 0.16-0.2% (Olatunji 2015). The critical level of N for maize is 0.15% (Ayodele and Omotoso 2007). However, soil organic matter was 2.18%, considered preferable for loamy soils, indicating a potential for high N release during the growing season. The available phosphorus level was 35.351mg/kg, which is moderate for soils in this ecological zone (Olatunji 2015)

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**Table 3.1: The Soil Physical and Chemical Properties before sowing**

| **Soil Properties** | **Values (2020)** |
|---|---|
| Soil pH | 4.69 |
| Organic matter (%) | 2.18 |
| Total nitrogen (%) | 0.05 |
| Available phosphorus (mg/kg) | 35.35 |
| ECd (s/m) | 0.13 |
| **Exchangeable Bases (Mg/kg):** | |
| $Ca_2^+$ | 2.44 |
| $Mg_2^+$ | 1.08 |
| $Na_2^+$ | 0.08 |
| $K^+$ | 0.11 |
| Effective cation exchange capacity (cmol/kg) | 6.17 |
| Base saturation (%) | 60.1 |
| Exchangeable acidity (cmol/kg) | 2.46 |
| **Particles Size Analysis** (%) | |
| Sand | 72.12 |
| Silt | 5.90 |
| Clay | 17.98 |
| Textural class | Loamy Soil |

**Growth parameters**

In 2020, plant height across treatments was between 109.86 to 153.66 cm. In 2021, plant height increased to 194-225 cm. There was no significant difference in plant height between treatments in both years of study. In 2020, TZM 109 and 386 produced plants with 152 and 153 cm, which was at least 30 cm taller than the local variety *Uwep*, but this difference, was not statistically significant. In 2021, TZM 386 (234 cm) and uwep (225 cm) produced one of the tallest plants, which was also not significantly different from the other accessions. However, a linear regression analysis in 2020 revealed a significant positive relationship between plant height and grain yield (across treatments) (figure 3.1). Plant height accounted for 24% of the variation in grain yield, indicating the contribution of this parameter to the grain yield. This result aligns with a study by Nzuve et al (2014) who showed that maize plant height was positively correlated with grain yield. They stated that high dry matter accumulation and increased number of leaves in taller plants contributed to the increase in grain yield.

Differences in plant height between cultivars have been reported by Yusuf, Musa, and Ifeoluwa (2019) and Akintunde (2024). They explained the differences because plant height is a genetically and environmentally controlled factor. TZM 386 emerged as one of the tallest (numerically) plants in both years -the average height was 234 cm in 2021, well over the generally expected height of these accessions (table 2.1). This desirable trait in TZM 386 can be exploited further and incorporated into breeding programs. However, in the first year of the study all exotic accessions did not reach the maximum height reported in the second year suggesting a possible limitation to factors encouraging plant height in the field site during the first year.

In 2020, the plant population at anthesis was between 36.50 -43.67, and in 2021 was between 36 and 46. This was lower than the expected population of 48 plants/plot. However, plant population results showed that there was moderate survival in all accessions. All accessions showed a survival rate of over 60 % (at anthesis), despite adverse factors such as insect attack and strong wind. A higher survival rate is more desirable as this may count towards higher ear numbers. There must be more efforts put in place to combat factors affecting the survival % of maize in the study site.

In 2020, measurements for plant lodging revealed an average of 3 plants/plot affected by lodging in the TZM 392 accessions. The local variety *Uwep* showed more resistance to lodging with as low as one plant/plot affected. However, there was no statistically significant difference between the accessions for this parameter $F(6, 21) = 1.145$ ($P = 0.372$). In 2021, TZM 386, 85, 16, 109, and uwep were the most vulnerable to lodging, with 6-13- plants/plot affected. While TZM 1330 and 392 were the most resistant to lodging, with only 3-4 plants affected/plot. According to Zhang et al (2022) a maize plant with lodging resistance is endowed with a large root system in the upper soil layer and apportions more photosynthates to its roots and lower stems. The accessions with lodging resistance in this studies TZM 1330 and 392 may be good candidates for lodging resistant- trait incorporation in maize breeding.

**Maize Yield Parameters**

Table 3.3 shows the average no of ears/ hectare for 2020 and 2021. In 2020, the ears produced were between 6-22 ears/experimental unit, which converted to 7,222 -42,222 ears/ha; there were significant differences between accessions $F(6, 20) = 4.584$ ($P = 0.004$). TZM 386 produced more ears (42,222.22) than the local accession *Uwep* (16,666.666), but there was no difference in ear numbers between TZM 386 and other exotic accessions. This indicates no difference in performance between other accessions under the environment and agronomic practices provided. In 2021, the range of ears produced per experimental unit was 22-34, which converts to 25,000-38000 ears/ha. Uwep appeared to have the lowest number of ears, but this difference was insignificant. There were no significant differences observed between all accessions for this parameter. However, ear numbers produced in 2021 exceeded those produced in 2020.

**Table 3.2: Agronomic traits for maize accessions in the 2020 and 2021 field experiment**

| **Accessions** | **Plant population/plot** | **Plant height (cm)** | **Total no of Lodging/plot** | **Plant population/plot** | **Plant height (cm)** | **Lodging** |
|---|---|---|---|---|---|---|
| *2020* | | | | 2021 | | |
| *Uwep* | 41.25 ± 1.49 | 118.37 ± 20.01 | 0.50 ± 0.50 | 42.25±1.65 | 225.5±20.79 | 7.25±4.425 |
| TZM 16 | 38.25 ± 2.05 | 132.32 ± 9.22 | 3.25 ± 0.75 | 45.75±1.11 | 208.8±9.02 | 6.5±2.64 |
| TZM 85 | 38.00 ± 2.95 | 143.53 ± 12.30 | 3.00 ± 0.95 | 40.5±4.84 | 216.5±18.9 | 8.00 ±2.483 |
| TZM 109 | 36.50 ± 2.75 | 153.67 ± 10.57 | 1.50 ± 0.65 | 46 ±0.91 | 194.5±12.18 | 5.25±2.75 |
| TZM 386 | 43.67 ± 1.45 | 152.28 ± 39.53 | 2.00 ± 1.53 | 39.5±7.51 | 234.5±8.0 | 13.50±2.646 |
| TZM 392 | 41.25 ± 1.55 | 109.86 ±21.52 | 3.75 ± 1.65 | 40±3.72 | 197.7±11.3 | 4.75±3.59 |
| TZM 1330 | 35.25 ± 2.02 | 114.88 ± 16.23 | 2.25 ± 1.03 | 46±0.41 | 222.9±9.5 | 3.75±0.854 |
| P value | NS | NS | NS | NS | NS | 0.014 |

**Table 3.3: Grain yield and yield components for maize accessions in the 2020 and 2021 field experiments**

| | Ear length (cm) | | Ear weight (husked) tn/ha | | Ear weight (dehusked) tn/ha | | No of ears/ha | | Grain yield tn/ha | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2020 | 2021 | 2020 | 2021 | 2020 | 2021 | 2020 | 2021 | 2020 | 2021 |
| *Uwep* | 24.77 ± 3.70 | 19.41±1.40 | 3.9722 ±1.38 | 5.92±2.29 | 3.88 ± 1.70 | 3.63±1.168 | 16,666.67 ± 8819.17 | 25,000 ±11129 | 0.1165 ± 0.08 | 1.25±0.39 |
| TZM 16 | 25.77 ± 1.80 | 17.25±1.69 | 5.3667 ± 0.74 | 8.02 ±1.85 | 2.36 ± 0.61 | 4.86±0.96 | 22,222.22 ± 2605.79 | 36,944.44 ± 8183.84 | 0.2498 ± 0.03 | 2.69±0.65 |
| TZM 85 | 26.79 ± 1.54 | 18.25±0.63 | 8.1167 ± 3.06 | 5.80±1.80 | 2.92 ± 0.34 | 4.06±1.28 | 23,888.89 ± 2740.49 | 31,944.44±14211.077 | 0.2664 ± 0.08 | 2.20±0.78 |
| TZM 109 | 24.41 ± 3.00 | 18.91±1.08 | 5.9306 ± 1.57 | 9.157±1.14 | 3.39 ± 1.08 | 5.53±0.94 | 23,333.33 ± 5111.92 | 36,111.11±6051.90 | 0.2638 ± 0.08 | 3.02±0.54 |
| TZM 386 | 30.99 ± 0.88 | 18.91±0.28 | 12.2296 ± 3.30 | 7.97±0.358 | 6.92 ± 1.26 | 5.21±0.50 | 42,222.22 ± 4206.60 | 35,555.56 ±3954.47 | 0.5923 ± 0.21 | 2.42±0.354 |
| TZM 392 | 27.65 ± 1.38 | 20.16±1.00 | 2.2222 ± 0.88 | 7.55±1.009 | 2.17 ± 0.76 | 4.104±0.92 | 14,722.22 ± 3122.17 | 30,277.78 ±10437.94 | 0.0695 ± 0.03 | 2.23 ± 0.63 |
| TZM 1330 | 16.96 ± 5.66 | 17.92±1.08 | 2.5000 ± 1.42 | 9.19±2.019 | 1.33 ± 0.52 | 6.01±1.32 | 7,222.22 ± 2957.17 | 38,333.33 ±9536.58 | - | 2.96± 0.44- |
| P value | NS | NS | 0.026 | NS | 0.033 | NS | 0.004 | NS | 0.003 | NS |

± Standard Error of Mean

In 2020, the ear fresh weight (husked) ranged from 2.22 – 12.23 tons/ha. Results for fresh ear weights (husked) were similar to results for ear no/ha. There were significant differences between accessions F (6, 20) = 3.106 (P = 0.026). TZM 386 weighed higher (12.2296) than *Uwep* (3.9722), and no differences were observed between TZM 386 and other exotic accessions.

Fresh weight (dehusked) was between 1.33 to 6.9 tons/ha. There was a statistically significant difference between accessions (F (6,20) = 2.917 (P=0.033). The weight of accession TZM 386 was higher than the local accession *Uwep,* and no difference was observed between other accessions. Furthermore, results for grain yield in 2020 showed statistically significant differences between accessions F(6,21) = 4.960 (P=0.003) (table 3.3). The average weight of grains for all accessions ranged from 0.1165 - 0.525 tons/ha. Accession TZM 386 produced more grains (0.525 tons/ha) than the local variety *Uwep*. Results for ear length showed no significant difference between all accession F (6, 20) = 1.818 (P = 0.146). Ear length was between (16.9643 -30.9879). TZM 386 gave the highest numerical length, but this difference was not statistically significant. In 2020, there were significant differences in ear width (P=0.014) between accessions, TZM 386 (14.9 ±1.61cm) was higher than Uwep (6.8 ±2.35 cm) but not higher than accessions (TZM 16=12 ±0.46 cm, TZM 109=12.8±1.69 cm, TZM 85=10.9 ±0.44 cm, TZM 392=6.93 ±2.59 and 1330=7.29 ±0.98cm). In 2021, no significant differences were observed between all accession for grain yield, ear weight (husked and dehusked), and ear length. Uwep produced the lowest yield, 1.25 tons/ha, and ear weights, 3.9 tons/ha (dehusked) and 5.92 tons/ha (husked), but these differences were not statistically significant.

A linear regression analysis for results in 2020 revealed there was a significant linear relationship between grain yield (across varieties) and ear no/ha (b = 1.083662e-11, se = 3.292e-06, p = 0.00197 **. Grain yield increased with an increase in ear numbers. Ear no accounted for 42 % of the variation in grain yield. No linear relationship was observed between ear length and grain yield.

When the results for 2020 and 2021 were combined in a multiple linear regression to determine the relationship between grain weight, ear no/ha, and plant height, there was a highly significant relationship between ear no and plant height on grain yield (P<0.001). The model containing ear no and plant height explained 85% variation in grain yield. This indicates a high dependence of grain yield on the growth parameter plant height and the yield parameter ear no/ha in all the accessions across 2020 and 2021. Plant height is a growth parameter that influences grain yield as crop increase in height implies increase in crop canopy to accommodate more capture of light and production of assimilates (Nzuve et al 2014). Grain number which is a parameter that also contributes to yield was associated with intercepted radiation (Jacobs and Pearson 1991). Kebede (2019) in a maize variety trial showed that the maize hybrid with increase grain yield also had increased plant height. Nzuve et al (2014) also reported a strong positive correlation between grain yield and plant height. TZM 386 in both years was among the tallest and maintained a grain yield comparatively higher than most accessions; this indicates the potential of plant height contributing to yield in this accession.
Ear weights and ear no/ha in this study varied from what has been previously reported in similar results in the same study area; Efretuei and Udounang (2020) reported ear weights (dehusked) of 1.5 tons/ha and ear no of 80,000-86,000/ha. Maize grain yield in the second-year trial was comparatively similar to the work by Obok et al. (2021)- their study performed in a similar ecological zone to compare performance of IITA maize accessions with a local variety reported yield between 1-4 tons/ha. A more recent study by Akintunde (2024) reported yields of 3-3-5 tons/ha The low yields in this study may be due to the early damage on stems caused by high insect infestation (as there was an incidence of stem borer attack in both years), even though this was subsequently controlled using a pesticide.

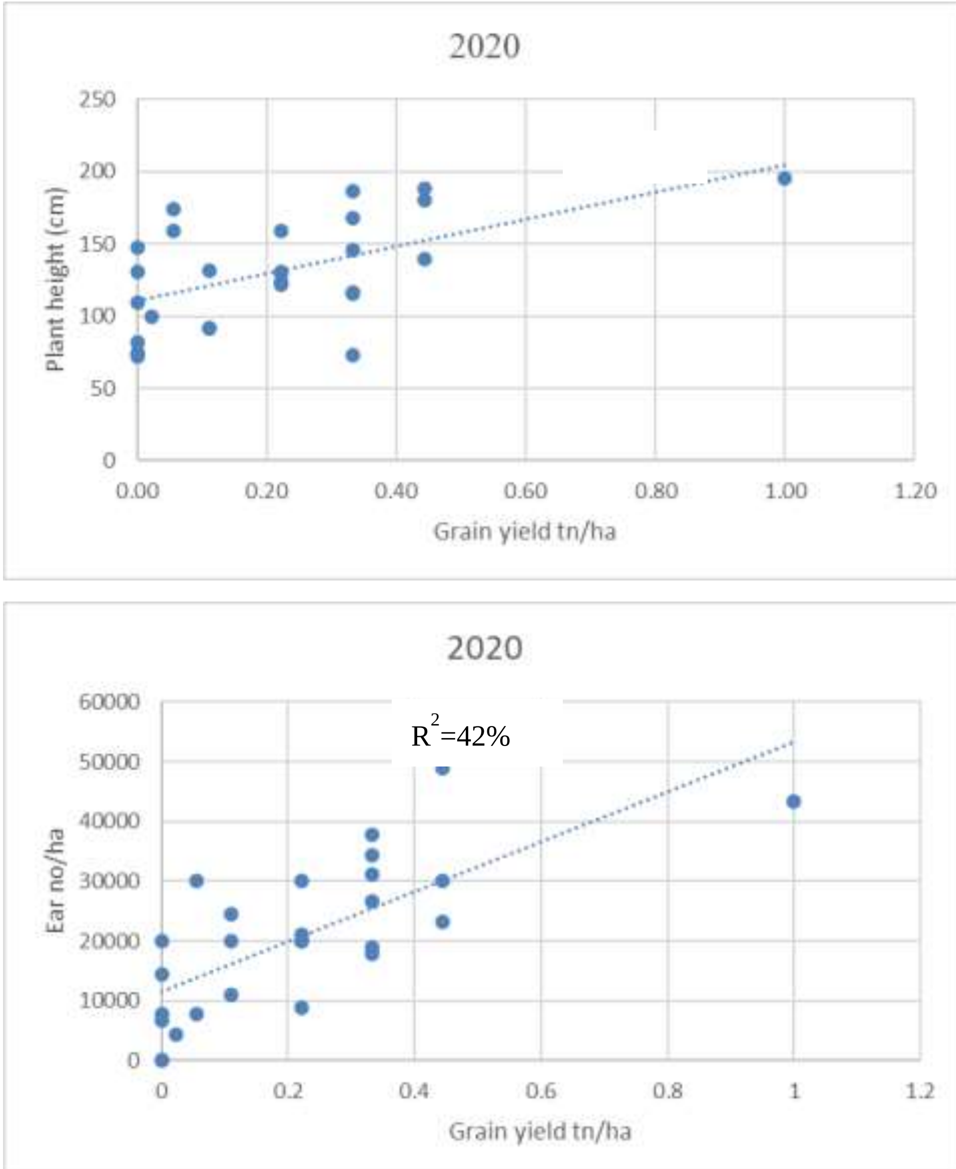


**Figure 3.1 scatter diagram showing the linear relationship between (a) grain yield and plant height (cm) and (b) grain yield and ear no/ha**

**CONCLUSION**

This study revealed maize grain yields for most accessions studied to be generally low compared to similar works. More exotic accessions need to be explored in this location to achieve increase in grain yield. It also reveals the contribution of agronomic traits such as plant height and ear number to maize grain yield. The accession TZM 386 showed potential for higher yield components (ear no and and ear weight) compared to the local variety (uwep) and other maize accessions in the 2020. It may be a promising candidate to explore in this study site

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