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A Comparative Analysis of Local Maize Hybrids, Versus Commercial Maize Hybrids: Assessing Yield and Yield Components

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A B S T R A C T

Genetic variability is an important factor for genotype selection in order to increase yield. A field experiment was conducted on "A comparative analysis of local maize hybrids, versus commercial maize hybrids: Assessing yield and yield components" was carried out at Cereal Crops Research Institute (CCRI) Pirsabak Nowshera during 2022, to check the performance of forty maize hybrids i.e., CHTW-1 to CHTW-40 along 2 checks (CS-220 and P30K08). Randomized complete block design (RCBD) was used with 3 replications. Two rows of each hybrid, each measuring five meters, were planted. The row-to-row and plant-to-plant distance maintained was 75 cm and 25 cm respectively. The seed rate used was 25 kg ha^{-1}. Statistical analysis of the data showed that maximum days to tasseling (60.67 days) were taken by check hybrid CS-220 while minimum days to tasseling (50 days) was noted in candidate hybrids CHTW-2 and CHTW-20. From the results it is concluded and recommended that the candidate hybrid CHTW-11 should be purchased and sown by the farmers as this is the finest, high yielding and cheaper as compared to other maize hybrids available in the market.

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INTRODUCTION

Maize (Zea mays L.) is an annual, cross-pollinated and major cereal grown throughout the world and is a major staple food for millions of people. It is referred to as the "queen of cereals" since it is a cereal crop that can be cultivated extensively, quickly, and for a short amount of time. No other cereal crop has such great potential (Begam et al., 2018). It is a classic multifunctional crop that is often farmed for food, fuel, feed & fodder, and industrial uses (KC et al., 2015), making it a vital crop for global food security and economic development. Because it has an energy density of 365 Kcal/100 g and comprises 72% starch, 10% protein, 9.5% fiber, and 4% fat, maize is regarded as a nutrient-rich diet and feed (Nuss and Tanumihardjo, 2010). It is the third most-produced cereal crop in the world, after rice and wheat, with a total area of over 170.9 million hectares under cultivation with 1.1 billion tons of production and 6360 kg ha-1 yield. It is grown in more than 160 countries worldwide and is the most important staple food in many developing countries, particularly in Latin America, Africa, and Asia (FAO, 2021). It is one of the most important cereal crops in Pakistan after wheat and rice, playing a crucial role in the country's food security and economy, with a total area of over 2.3 million hectares under cultivation with 8,465 tons production and 5,970 kg ha^{-1} yield (MNFS&R, 2021). In the Khyber Pakhtunkhwa province, it is grown on a total area of over 0.2 million hectares under cultivation with 904.5 tons of production and 1933 kg ha^{-1} yield (ASKP, 2021).

A hybrid variety is created by crossing two capable combiners in a specified way. Hybrid vigor, or heterosis, a phenomenon that frequently manifests as better yield and other desirable qualities, is thought to be the cause of hybrid varieties' superiority (Koemel et al., 2004). Plant breeders have found developing hybrid types of crops where they have not previously been economically exploited to be an appealing topic of research. The use of heterosis in agricultural production is crucial, and maize is one of the most effective instances in terms of crops (Duvick, 2001). In plants, heterosis may result from the interplay of many loci, depending on hybrids and characteristics (Schnable and Springer, 2013), flowering-related features (Krieger et al., 2010), yield (Luo et al., 2001), and tolerance to abiotic and biotic stressors (Miller et al., 2015). Additionally, the hybrids are more stable than pure lines, making them more adaptable to a variety of environmental conditions (Gowda et al., 2010; Mühleisen et al., 2014).

New hybrids are developed that bring a revolutionary change in yield per unit area worldwide. In order to forecast yield performance of varieties and agronomic treatments across environments, it is vital to conduct multi-environmental experiments in plant breeding and agronomy (Vaughan and Judd, 2003). However, commercially available maize hybrids are often marketed at high prices due to their perceived superiority over locally developed maize hybrids. The high cost of these commercial hybrids may make them inaccessible for small-scale farmers, who often rely on locally developed maize hybrids. Furthermore, the performance of locally developed maize hybrids may be underestimated due to a lack of rigorous evaluation. Therefore, there is a need to evaluate the performance of locally developed maize hybrids in comparison with commercial maize hybrids for yield potential. This study was designed to check the yield potential of locally developed maize hybrids as compared to the national and multi-national maize hybrids.

LITERATURE REVIEW

Adhikari et al. (2021) conducted an experiment on three hybrid maize varieties (10V10, Rajkumar F1, and NMH-731). The findings revealed that grain yield and yield contributing characteristics varied between hybrids. In comparison to other varieties, the hybrid maize variety 10V10 produced the highest grain yield (9.35 t ha^{-1}), net returns (NRs. 91740.66 ha^{-1}) and B:C ratio (1.91) as well as the maximum cob length (16.25 cm) and number of grains per row (32.35). This study concluded that in the inner Terai area of Nepal, maize output may be maximized by farming hybrid maize variety 10V10 with 220 kg N ha^{1}.

Bastola et al. (2021) evaluated five genotypes of white maize in four replications in a randomized complete block design, with Deuti used as the standard check. Deuti and DMH-7314 performed well in terms of remaining green and husk cover. In HB-008 there were greater plant heights (282.6 cm) and ear heights (162.4 cm). The number of kernels per row was greater in HB-008 (36.5) and HB-007 (36.5), but the thousand kernel weight was greater in DMH-7314 (386.3 g), followed by Deuti (353.9 g). The shelling percentage of DMH-7314 was lower (70.8%) than that of the other varieties, despite its late tasseling (86 days) and silking (89 days). ANOVA revealed that genotype HB-008 (9.70 t/ha) outperformed the standard check Deuti (7.80 t/ha). Thus, in the mid-hill area of Kavre, Nepal, genotype HB-008 performs better.

Erdurmus et al. (2021) experimented with Antalya and Konya sites in Turkey during 2014-2015, using 48 chosen forage sorghum lines and four sorghum cultivars. A randomized complete block design with three replications was used for the experiment. All characteristics showed significant variation among genotypes. The maximum plant height was 355.2 cm in Antalya and 300.1 cm in Konya. Antalya's greatest plant height was 355.2 cm, whereas Konya's was 300.1 cm. Line-22 in Antalya had the greatest forage yield of 99.1 tha^{-1}, followed by Line-41 in Konya, which had 75.5 tha^{-1}. Hay yield ($r = 0.9851^{**}$), plant leaf ratio ($r = 0.3478^{*}$), and stalk yield ($r = 0.9901^{**}$) all showed a strong and positive correlation with forage yield. Path analysis demonstrated that the plant stalk ratio had a direct positive impact on fodder output. Plant stalk yield, on the other hand, had a negative direct impact on fodder yield. The most stable varieties were Lines 1, 3, 5, 13, 21, 40, 42, and 44, according to the stability analysis results.

Magar et al. (2021) tested 10 maize genotypes using a randomized complete block design (RCBD) with three replications from June to September 2019. The findings revealed that the genotypes differed significantly across all characteristics. The genotypic coefficient of variation (GCV) was lower for every characteristic than the phenotypic coefficient of variation (PCV). The maximum PCV (26.91%) and GCV (25.9%) were found in the grain yield, while the lowest PCV (4.07%) and GCV (6.05%) were found in the leaf width at maturity. The attributes with the lowest Genetic Advancement over Mean (GAM) values were days to 50% anthesis at 0.1% and the highest GAM value (51.36%) was grain yield. Grain yield (0.93, 51.36%) and 1000 grain weight (0.99, 36.95%) had higher heritability and GAM% values than leaf length (0.5, 7.25%) and leaf width (0.39, 5.25%) which had the lowest heritability and GAM% values. Test weight (r ¼ 0.706), cob length (r ¼ 0.671), cob diameter (r ¼ 0.573), and number of rows per cob (r ¼ 0.539) all exhibited positive and substantial phenotypic correlations with grain yield. As a result, features with significant variation can be employed as selection indicators for indirect selection to increase maize production.

Neupane et al. (2020) investigated fourteen hybrid maize genotypes. There were significant variations in quantitative characteristics across the studied genotypes. Grain yield showed significant variance between genotypes. The Pioneer genotype produced the maximum yield (11.98 mt/ha), whereas the RL-24-0/RL-111 genotype produced the lowest (5.53 mt/ha). In contrast, the check variety Rampur Hybrid-10 produced 8.23 mt/ha.

Bhanbhro et al. (2019) studied the performance of seven genotypes of wheat obtained from CIMMYT, Mexico checked with two local wheat varieties in terms of yield and its components. Analysis of data showed that each parameter is significantly different. It was concluded from the results that maximum grain yield was recorded by the cultivar G-93 and hence, recommended for general cultivation.

Kausar et al. (2018) investigated the performance of six high-yielding wheat varieties. Data analysis revealed that each wheat variety's performance had a significant effect on all yield and yield component parameters. The variety NARC-2009 had the highest grain yield (3590.39 kg ha^{-1}), followed by the variety Pakistan-13 (3570.63 kg ha^{-1}).

Kandil (2013) analyzed four different maize hybrids: one two-way cross (329) and three single crosses (122, 129, and 10). The comparison showed a significant difference in the characteristics of maize yield and growth flourishment. A single cross-10 produced significantly increased biomass and yield attributes.

METHODOLOGY

The experiment comparison of local maize hybrids with commercial maize hybrids for yield and yield components was conducted at Cereal Crops Research Institute (CCRI) Pirsabak, Nowshera in 2022. Seeds of 40 candidate hybrid lines (CHTW) of white maize (Zea mays L.) along 2 checks (CS-220 and P30K08) were sown by dibbling on a well-prepared seed bed in a randomized complete block design (RCBD) with 3 replications during August 2022. Each hybrid was planted in two rows, each measuring 5 m long, with plants 25 cm apart and rows 75 cm apart. The seed rate used was 25 kg ha^{-1}. Two seeds were sown to create a strong plant stand, and following germination, thinning was done to get one healthy seedling. Non-experimental lines were planted at the start and end of each block to counteract the border effect. The whole growing season saw the application of cultural techniques as advised for the maize crop.

Table 1. List of Maize Hybrids That Were Used in the Experiment

CHTW-1	Candidate	CHTW-22	Candidate
CHTW-2	Candidate	CHTW-23	Candidate
CHTW-3	Candidate	CHTW-24	Candidate
CHTW-4	Candidate	CHTW-25	Candidate
CHTW-5	Candidate	CHTW-26	Candidate
CHTW-6	Candidate	CHTW-27	Candidate
CHTW-7	Candidate	CHTW-28	Candidate
CHTW-8	Candidate	CHTW-29	Candidate
CHTW-9	Candidate	CHTW-30	Candidate
CHTW-10	Candidate	CHTW-31	Candidate
CHTW-11	Candidate	CHTW-32	Candidate
CHTW-12	Candidate	CHTW-33	Candidate
CHTW-13	Candidate	CHTW-34	Candidate
CHTW-14	Candidate	CHTW-35	Candidate
CHTW-15	Candidate	CHTW-36	Candidate
CHTW-16	Candidate	CHTW-37	Candidate
CHTW-17	Candidate	CHTW-38	Candidate
CHTW-18	Candidate	CHTW-39	Candidate
CHTW-19	Candidate	CHTW-40	Candidate
CHTW-20	Candidate	CS-220	Check
CHTW-21	Candidate	P30K08	Check

Data were documented on the following parameters:

a. **Days to Tasseling**: It is the period of time between the date of planting and the appearance of the male flower in the crop.
b. **Days to Silking**: Days to silking were calculated as the interval between the sowing date and the appearance of the female flower.
c. **Plant Height (cm)**: On five randomly chosen plants, plant height was measured at physiological maturity from the ground to the tip of the tassel, and the data were averaged for the mean.
d. **Ear Height (cm)**: On five randomly chosen plants, the height of the primary ear was measured from the ground up, and the data were averaged for the mean.
e. **Number of Ears ha^{-1}**: Prior to harvest, each plot's total number of ears was recorded and the results were converted to number of ears ha^{-1}.
f. **Number of Plants ha^{-1}**: Before harvest, the total number of plants in each plot was counted, and the data changed into the number of plants ha^{-1}.
g. **Grain Yield (kg ha^{1})**: Following Carangal et al. (1971)'s guidelines, grain yield for each entry was determined and approximated using the formula below:

$$\text{Grain yield (kg ha}^{-1}\text{)} = \frac{Fresh\ ear\ weight\ (kg\ plot^{-1})\ x\ 100 - MC\ x\ 0.8}{Area\ harvested\ x\ (100-15)}\ x10000$$

Where:
Fresh ear weight: Fresh weight of the ears
MC: Moisture content in the grains at harvest time
0.8: Shelling coefficient
85: Grain moisture standard value at 15%

h. **Statistical Analysis**: The analysis of variance approach, as suggested for RCB design by Steel and Torrie (1980), was used to the data.

RESULT AND DISCUSSION

Days to Tasseling

Data concerning days to tasseling are presented in Figure 1. Analysis of the data showed that maize hybrids differed significantly for days to tasseling. Late tassels (60.67 days) were observed in check hybrid CS-220 followed by candidate hybrid CHTW-33 (57 days). Early tassels (50 days) were noted in candidate hybrids CHTW-2 and CHTW-20. These results are consistent with Hussain et al. (2014) and Khan et al. (2019). Khan et al. (2019) demonstrated that different maize hybrids have a significant effect on days to tasseling which is an indicator of the degree of ripeness, along with other associated maturity traits are used by agronomists and breeders to assess ripeness duration in maize crops. The differences in days to tasseling observed in this study could be attributed to variations in the genetic makeup of the hybrids, which in turn affects the expression of genes involved in flowering time.

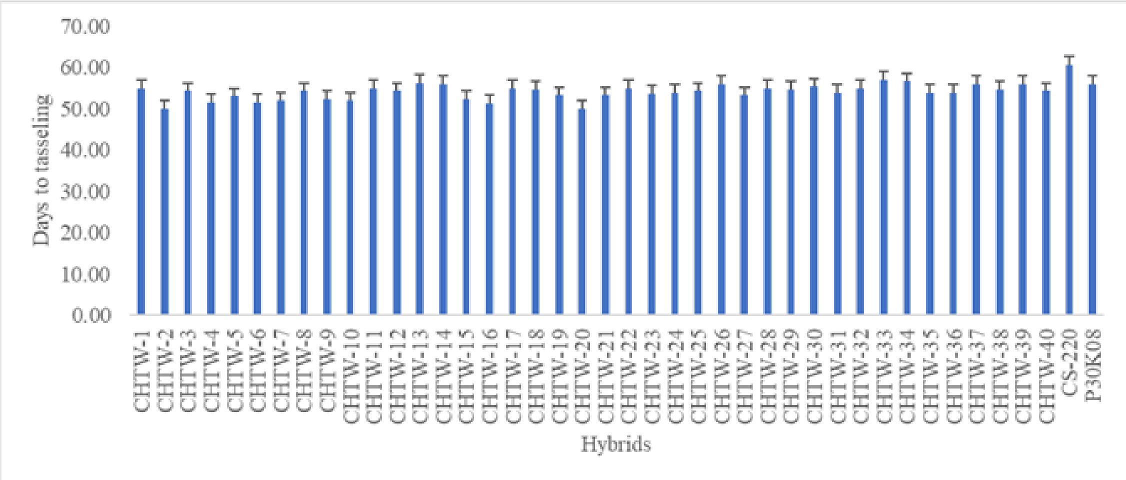

Figure 1. Days to Tasseling of Maize as Affected by Different Hybrids

Days to Silking

Data regarding days to silking are given in Figure 2. Analysis of the data showed that maize hybrids had significantly affected days of silking. Delayed silking (64.67 days) was noted in check hybrid CS-220 followed by candidate hybrid CHTW-13 (60 days). Earlier silking (53.67 days) was taken by candidate hybrid CHTW-20. These findings are in line with Hussain (2011) who also reported that maize varieties significantly differed in days of silking. However, Ige et al. (2019) discussed that maize genotypes did not differ significantly for the days to silking. Early silking is desirable for reducing the time required for pollination and increasing the likelihood of successful pollination in areas with a short growing season. Late silking, on the other hand, can be advantageous in regions where prolonged periods of high humidity or rainfall may increase the risk of pollination failure due to fungal infections.

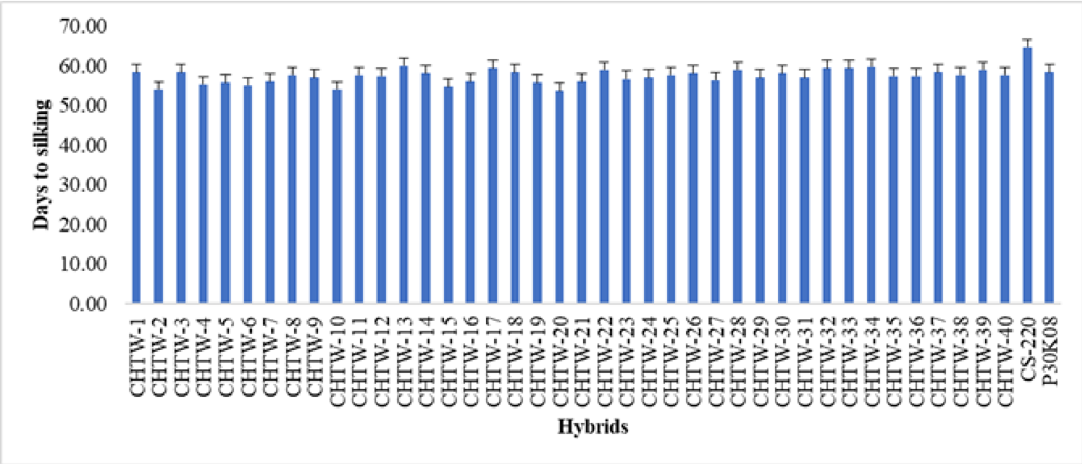

Figure 2. Days to Silking of Maize as Affected by Different Hybrids

Plant Height (cm)

Data referring to plant height (cm) are provided in Figure 3. Analysis of the data revealed that maize hybrids had significantly influenced plant height. Taller plants (155.33 cm), (155.33 cm) and (152.00 cm) were produced by candidate hybrids CHTW-13, CHTW-21 and CHTW-11 respectively. Shorter plants (104.53 cm) were produced by candidate hybrid CHTW-37. These results are consistent with Bastola et al. (2021) who stated that there was a significant variation between varieties of maize on plant height. Previous research on maize hybrids has shown that genetic factors can significantly influence plant height (Kamara et al., 2013; Abid et al., 2016). It is important to understand the genetic basis of these traits to develop new hybrids with desirable characteristics, such as increased yield or improved resistance to pests and diseases. This suggests that these hybrids have a genetic predisposition towards taller plant growth, which could be due to their genetic makeup or environmental factors.

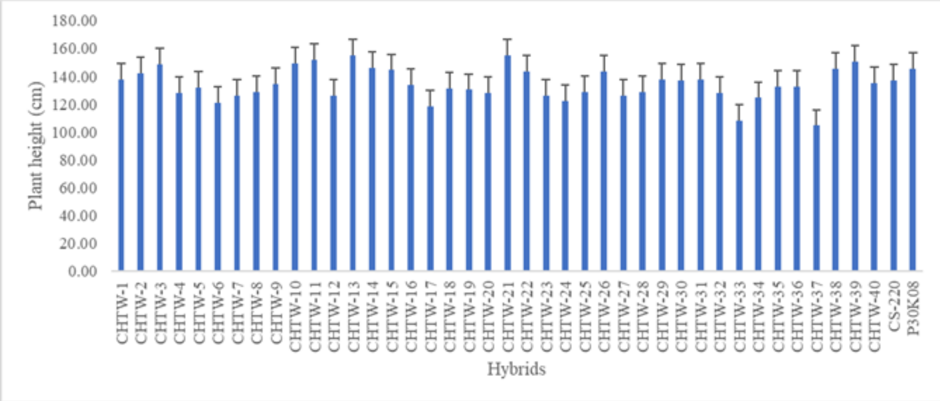

Figure 3. Plant Height (cm) of Maize as Affected by Different Hybrids

Ear Height (cm)

Data relating to ear height (cm) are imparted in Figure 4. Analysis of the data showed that maize hybrids had significantly influenced ear height. Maximum ear height (82.23 cm) and (81.43 cm) were recorded in candidate hybrids CHTW-21 and CHTW-11 respectively. Minimum ear height (46.30 cm) was produced by candidate hybrids CHTW-6 and CHTW-17. These findings are similar to Bastola et al, (2021) who reported that the significant differences in ear height among the candidate maize hybrids in this study can be logically attributed to genetic variability, environmental factors, gene interactions, and phenotypic plasticity.

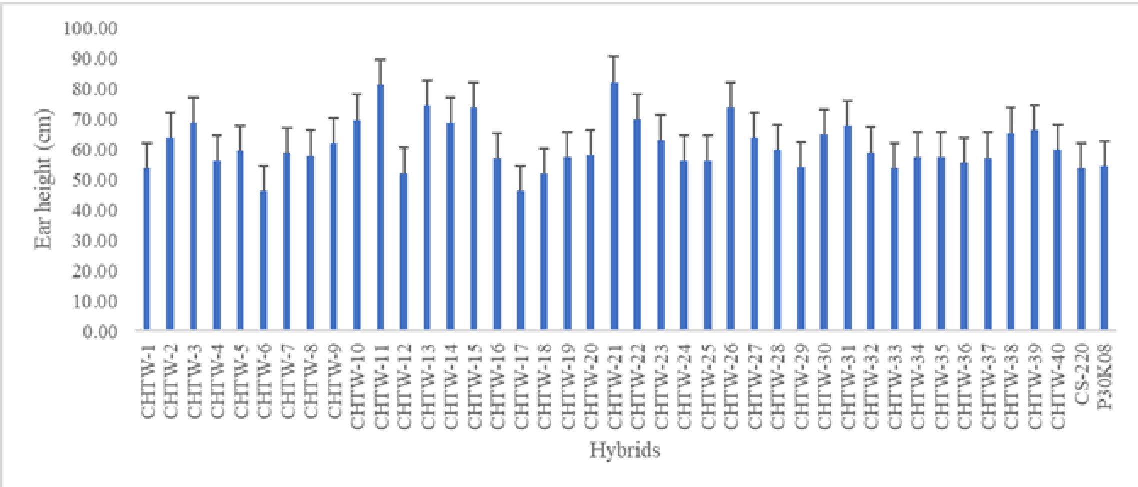

Figure 4. Ear Height (cm) of Maize as Affected by Different Hybrids

Number of Ears Ha^{-1}

Data denoting the number of ears ha^{-1} are shown in Figure 5. Analysis of the data revealed that maize hybrids differed significantly for the ear population. A higher number of ears ha^{-1} (52889 ears ha^{-1}) was observed in candidate hybrid CHTW-11. The lower number of ears ha^{-1} was recorded in check hybrid CS-220 (13844 ears ha^{-1}). Duvick (2005) interpreted similar results, however, Ali et al. (2020) reported that there is no significant effect of maize hybrids on the number of ears ha^{-1}. The higher ear population per hectare in the candidate hybrids could be attributed to their genetic makeup and/or their response to management practices. It is well-known that genetic factors play a significant role in determining yield potential and yield stability in maize. In addition, the management practices used in the experiment could have influenced the ear population. For instance, soil fertility, plant density, and weed control could affect the number of ears per hectare (Oyekunle et al., 2020).

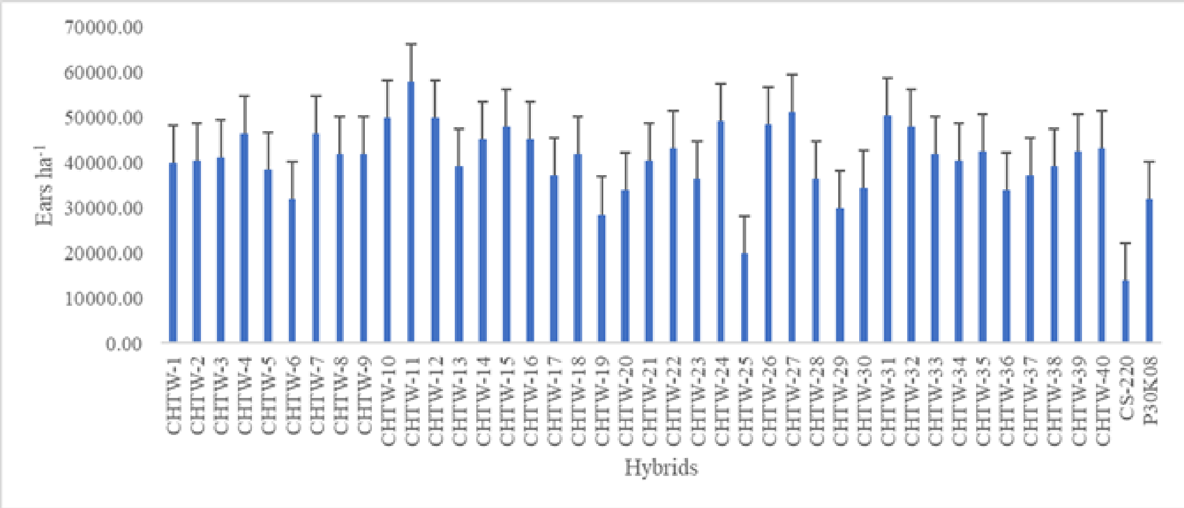

Figure 5. Number of Ears Ha^{-1} of Maize as Affected by Different Hybrids

Number of Plants Ha^{-1}

Data relating number of plants ha^{-1} are given in Figure 6. Analysis of the data showed that maize hybrids had not significantly differed for plant population ha^{-1}. These results are in line with the findings of Ali et al. (2020) who reported that maize hybrids have no significant effect on plant population ha^{-1}. There could be several reasons for the lack of significant differences observed among the tested hybrids. One possible reason could be uniform planting geometry i.e., it is sown through dibbling method. It could also be due to that the hybrids were developed using similar breeding strategies and had comparable genetic backgrounds. However, Li et al. (2019) has shown that genetic factors can play a significant role in determining the yield potential and plant population of maize hybrids.

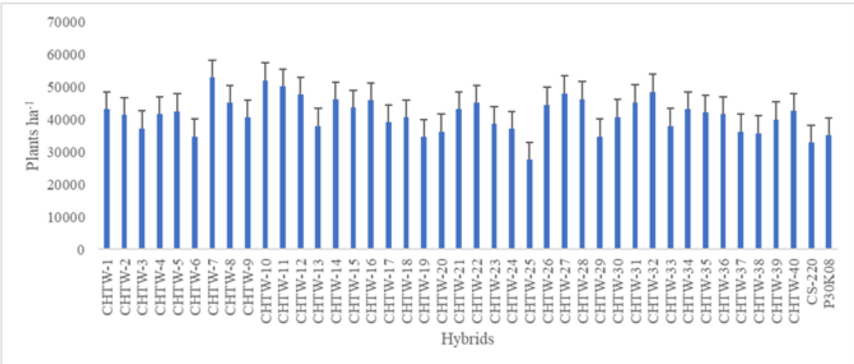

Figure 6. Number of Plants ha^{-1} of Maize as Affected by Different Hybrids

Grain Yield (kg ha^{-1})

Data concerning grain yield are presented in Figure 7. Analysis of the data revealed that maize hybrids had a significant effect on grain yield. A higher grain yield (9273.70 kg ha^{-1}) was produced by candidate hybrid CHTW-11. A lower grain yield (4603.70 kg ha^{-1}) was produced by check hybrid CS-220. These results are at par with Ali et al. (2020) who indicated that maize hybrid varied significantly for grain yield. Similarly, Shrestha (2016), and Hussain et al. (2004) also found highly significant differences in maize varieties for grain yield. Their findings revealed that the variation in grain yield obtained from different hybrids can be attributed to its genetic makeup, which may include favorable genes for yield traits such as ear size, number of kernels per ear, and kernel weight. These traits are controlled by several genes that interact with the environment, and their expression can be affected by factors such as temperature, water availability, and nutrient availability.

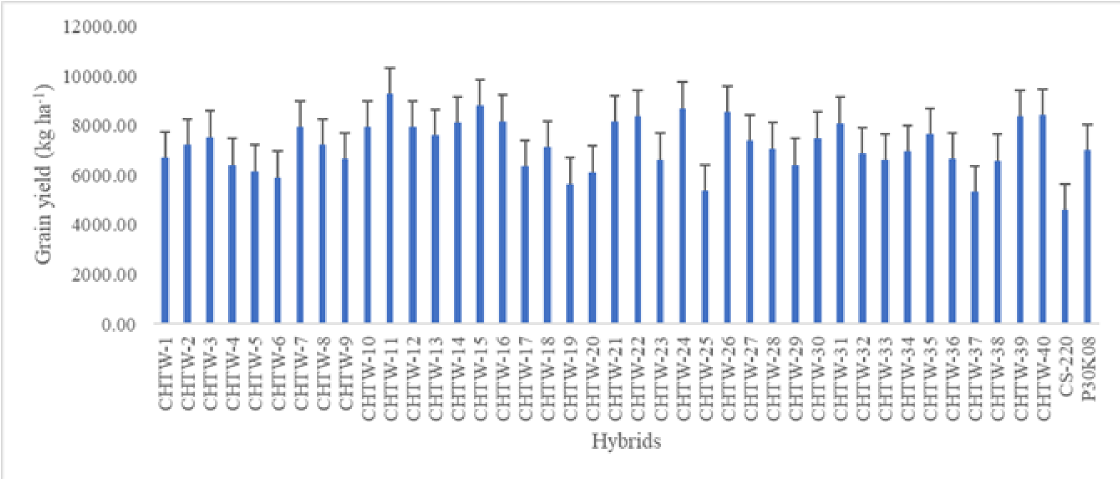

Figure 7. Grain Yield (kg ha^{-1}) of Maize as Affected by Different Hybrids

CONCLUSIONS AND RECOMMENDATIONS

From this experiment, it is concluded that maximum grain yield (9273.70 kg ha^{-1}) was produced by candidate hybrid CHTW-11 as compared to other maize hybrids in the experiment. This is the finest maize hybrids for agroclimatic conditions of Peshawar. The hybrid gave good results instead to other hybrids in the experiment. CHTW-11 stands out as an excellent choice for farmers due to its combination of high yield potential, quality attributes, cost-effectiveness, adaptability, resilience, and local suitability. Choosing this hybrid can lead to improved profitability and sustainability in maize production, making it the finest and most economical option compared to other hybrids available in the market. Farmers are encouraged to consider CHTW-11 as their preferred choice for maize cultivation.

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FURTHER RESEARCH

This research still has limitations so further research needs to be done on this topic “A Comparative Analysis of Local Maize Hybrids, Versus Commercial Maize Hybrids: Assessing Yield and Yield Components”.

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