Research Article

Evaluation of Yellow Maize Candidate Population for Yield and Associated Traits

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Abstract | During the Kharif season of 2022, an experiment was carried out at the Agricultural Research Station, Swabi, Khyber Pakhtunkhwa, Pakistan, to evaluate the yield and yield-related features of three local landraces and one exotic maize variety of yellow genotypes. A Randomized Complete Block Design with three replications was used to evaluate the genotypes. With the exception of days to maturity, there were highly significant differences among the maize genotypes for almost all traits. Genotype 'Saleem Khan-2' had the maximum days to tasseling, whereas the 'Bamkhel-2' genotype had the shortest. The genotypes 'CIMMYT Yellow' and 'Saleem Khan-2' took the maximum number of days to silking, while 'Bamkhel-2' had the minimum days. Genotype 'Eidhi' had the lowest plant height, whereas genotype 'Bamkhel-2' had the highest. Genotype 'Bamkhel-2' had the highest leaf area measured, whereas 'Eidhi' had the lowest. The highest grains per ear were noted for genotype 'Bamkhel-2' (567.40), and the minimum was recorded in 'Saleem Khan-2' (448.53). The genotype 'CIMMYT Yellow' achieved the highest thousand-grain weight (331.40g), whereas the genotype 'Eidhi' had the highest grain weight (305.00 g). Similarly, the genotype 'Bamkhel-2' produced the highest yield (7502.22 kgha^{-1}), followed by 'Saleem Khan-2' (7306.67 kgha^{-1}), while 'CIMMYT Yellow' (5560.00 kgha^{-1}) ranked inferior in terms of yield.

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Introduction

The crop maize (*Zea mays* L.) is utilized both for feed and food production worldwide. It is one of the most valuable and extensively cultivated cereal crops, significantly contributing to food security in developing countries of Asia and Africa. Maintaining high-quality and sustainable corn production requires a crucial focus on soil nutrient status. Compared to all other cereal crops, maize can produce the highest grain yield per unit area due to its unique energy-collecting abilities and effective use of CO_2 as a C_4 plant (Sardar *et al.*, 2022). In terms of kernel production per hectare, it is the most productive cereal crop (Yousaf *et al*., 2021).

In 2017, global maize production was 1134.74 million metric tons, with an average yield of 5754.7 kgha^{-1} from a land area of 197 million hectares. The United States was the leading producer with 370.96 MMT, followed by China (259.23 MMT), Brazil (97.72 MMT), Argentina (49.47 MMT), and India (28.72 MMT). Pakistan was the 22nd largest maize producer in the world in 2017 (FAO, 2019; Dohlman *et al*., 2022). On the other hand, in Pakistan, maize ranks as the third most significant grain crop after rice and wheat. Due to the availability of tropical and temperate genetic material in hybrids and open-pollinated types, Pakistan cultivates maize in both the spring and Kharif seasons (Ali *et al*., 2018; Ullah *et al*., 2005). In Pakistan, 10.18 million tons of maize were produced in 2017 with a yield of 5,922 kgha^{-1} on 1,720 thousand hectares of land. Maize contributes 3.0 percent to the agricultural value and 0.7 percent to GDP (GOP, 2022). Punjab is the top maize-producing province in Pakistan, with an annual output of 5,237.1 million tons and a yield of 6,032 kg per hectare.

Despite the high potential of existing maize varieties, current production levels are below optimal due to factors such as plant density, improper fertilizer application, inadequate water availability, biotic and abiotic stresses, weed infestation, insect pest damage, and unsuitable cultivar selection. A significant issue is the lack of high-quality seeds for better maize genotypes, particularly hybrid maize. Only 28 to 30 percent of the maize-growing area is used for hybrid crops (Ali *et al*., 2020).

To overcome this issue, different maize breeding programs are carried out with the objective of identifying and developing high-yielding and early-maturing maize hybrids and synthetic cultivars (Hussain *et al*., 2016). The purpose of this study was to evaluate and identify early-maturing and high-yielding maize genotypes.

Materials and Methods

An experiment was conducted to evaluate different yellow maize genotypes at the Agricultural Research Station, Swabi (Pakistan) during the Kharif season of 2022. The experimental material consisted of four genotypes: 'Bamkhel-2', 'Saleem Khan-2', 'CIMMYT Yellow', and 'Eidhi' as the check type. On June 27, 2022, the study material was manually planted using a Randomized Complete Block Design (RCBD) with three replications. Each replication consisted of two rows, each three meters in length and 70 cm apart. Cultural practices were carried out in accordance with the maize recommendation package per the region. Data was recorded on the following traits of interest in the given environment.

Days to tasseling

Days to tasseling were recorded by counting the number of days from sowing to the date when 80% of the plants produced tassels in each subplot.

Leaf area

Five plants were chosen at random from each plot, their length and breadth measured with a ruler, and their leaf area calculated using the formula below:

$$\text{Leaf area } (cm^2) = \text{Leaf length x Leaf width x Factor}$$

Days to silking

Days to silking were tallied from the first day of sowing to the day when 80% of the plants in each subplot produced silks.

Anthesis silking interval

This determines the number of days between the expulsion of pollen and the emergence of silk.

Plant's height (cm)

The length of five randomly chosen plants from each subplot was measured from the lowest point to the top of the plant, including the tassel, at physiological maturity using a measuring rod.

Ears plant^{-1}

The average number of ears was estimated from ten randomly picked plants from each plot.

Rows ear^{-1}

From each genotype, five ears were chosen at random. The number of grain rows on each ear was noted, and the total number of rows was recorded.

Grains row^{-1}

For each entry, the grains in each cob row were counted from five randomly picked ears.

Grains ear^{-1}

The number of grains per ear was computed by picking five ears from each plot, drying them, and counting the grains.

Weight in grams of 1,000 grains

The weight of 1,000 grains was recorded using a precise electronic balance after counting with a seed counter for each plot's seed lot.

Grain yield (kg ha⁻¹)

The seed yield of each entry was converted to kg ha^{-1} using the following formula:

$$Seed\ yield\ in\ kg\ ha^{-1} = \frac{Yield\ in\ kilograms\ x\ 10{,}000}{No.of\ rows\ x\ Row\ spacing\ x\ Row\ length}$$

Statistical analysis

According to Steel and Torrie (1980), the data obtained for each parameter underwent analysis of variance (ANOVA). To test the null hypothesis that there is no difference in traits between the genotypes, Statistix 8.0 was applied.

Results and Discussion

Days to tasseling

Days to tasseling are significant because they signal the start of pollination, which affects kernel growth and overall yield. Tasseling too soon or too late affects the timing of silk emergence, which may impact crop output and fertilization success. Highly significant differences among all the genotypes were found for days to tasseling (Table 1). Mean days to tasseling ranged from 57.33 to 62.33 days (Table 2). 'Saleem Khan-2' had the highest number of days until tasseling, whereas 'Bamkhel-2' had the least. Our findings are consistent with those of Ali *et al.* (2020), who also reported substantial variations in days to tasseling in maize. However, the variation in days to tasseling was significant in the inbred population (Ullah *et al*., 2021).

Days to silking

Days to silking, which directly affects kernel set and yield, is a crucial indicator in the growing of maize because it signals when the ears are ready to receive pollen. To ensure proper pollination and optimize crop output, silking and tasseling must occur simultaneously. The analysis of variance for time to silking displayed highly significant variations among all the genotypes ($p \leq 0.01$) (Table 1). The duration to complete silking ranged from 62 to 64 days. The genotypes 'Saleem Khan-2' and 'CIMMYT Yellow' had the most days to silking, whereas 'Bamkhel-2' had the fewest (Table 2). Our results are in line with the findings of Qureshi and Khalil (2019), who also showed substantial variations in days to silking.

Anthesis silking interval

The anthesis-silking interval (ASI) plays a vital role in maize production. A shorter ASI provides greater synchronization between pollen discharge and silk emergence, improving fertilization rates and increasing grain production. Significant genotype differences were discovered in the anthesis-silking interval, with a substantial level of significance at a probability threshold of 1% (Table 1). The ASI for the genotype 'Eidhi' reached a maximum value of 3.75 days (Table 2), suggesting a prolonged lag between

Table 1: *Mean Squares of yellow maize genotypes evaluated for various morphological and yield parameters.*

SOV	DF	Days to tasseling	Days to silking	ASI	Leaf area (cm)	Plant height (cm)	Days to maturity	Grains per ear	Thousand grain weight	Yield in kgha⁻¹
Replications	2	7.58	6.25	0.06	9.08	0.723	2.25	4.52	4.11	15
Genotypes	3	14.97**	2.75**	0.52**	7607.96**	682.68**	5.00ns	8466.15**	378.97**	2693709**
Error	6	0.47	0.25	0.01	0.44	1.25	1.58	0.26	0.009	123155
CV%		1.13	0.79	2.45	0.19	0.51	1.36	0.10	0.03	5.31

*** Significant at 1% level of probability; * Significant at 5% level of probability; ns: Non significant.*

Table 2: *Means of yellow maize genotypes evaluated for various morphological and yield parameters.*

Genotypes	Days to silking	Days to tasseling	Days to maturity	ASI	Leaf area (cm)	Plant height (cm)	Grains per ear⁻¹	1000 grain weight	Yield (kgha⁻¹)
Bamkhel-2	62	57.33	92	3.60	421.13	232.50	567.40	322.60	7502.22
CIMMYT yellow	64	61.67	94	3.32	346.51	210.03	471.53	331.40	5560.00
Saleem Khan-2	64	62.33	91	2.80	355.69	227.40	448.53	315.30	7306.67
Eidhi	63	61.00	93	3.75	298.76	200.07	522.07	305.00	6053.33

anthesis and silking. The genotype 'Saleem Khan-2', on the other hand, displayed a minimum value of 2.80 days, indicating a shorter time between anthesis and silking for this genotype. Noor *et al*. (2010) observed similar findings, noting significant variations in the ASI among maize genotypes.

Days to maturity

Days to maturity is an essential trait for plants, indicating how long a plant requires to reach the reproductive stage, generate seeds, and complete its life cycle. Additionally, it aids in the planning of agricultural techniques like crop rotation and harvesting. No significant differences among the treatments were found in the analysis of variance for days to maturity (Table 1). The observed days to maturity ranged from 91 to 94, suggesting a close range of maturation periods across the experimental conditions. 'Saleem Khan-2' had the shortest days to maturity, whereas the genotype 'CIMMYT Yellow' had the longest (Table 2). Khan *et al*. (2018) also found no significant variations in the number of days until maize is fully mature.

Plant height

A plant's height is a quantitative trait that provides stature and support. According to the analysis of variance for plant height, all genotypes differed from one another at an average probability of 1%. As shown in Table 2, plant heights varied from 200.07 cm to 232.50 cm. The 'Bamkhel-2' genotype had the highest reported plant height, whereas the 'Eidhi' genotype had the lowest. Khan *et al*. (2014) also noted large variations in maize plant height.

Leaf area

Leaf area is vital for plants as it directly impacts their ability to photosynthesize and overall production. All genotypes differed significantly from one another at a probability level of 1%, according to the analysis of variance for leaf area (Table 1). As shown in Table 2, the leaf area varied from 298.76 cm^2 to 421.13 cm^2. The 'Bamkhel-2' genotype had the largest leaf area measured, while 'Eidhi' had the smallest. Our findings are consistent with those of Muhammad *et al*. (2019), who also observed significant variations in maize leaf area.

Grains ear

The number of grains ear^{-1} significantly influences plant production and overall productivity. The results showed a substantial difference in grains ear^{-1} among the genotypes investigated (Table 1). The 'Bamkhel-2' genotype achieved the highest score of 567.40 (Table 2), highlighting its outstanding characteristics and potential for increased grain output. In contrast, 'Saleem Khan-2' achieved a lower score of 448.53, demonstrating poorer performance in terms of grain output. Mtyobile (2021) also observed notable disparities in grains ear^{-1}, supporting our findings.

Grain yield

The assessed genotypes for grain yield showed substantial variances (Table 1). The grain yield data ranged from 5560.00 to 7502.22 kg ha^{-1}. The genotype 'Bamkhel-2' provided the highest yield, whereas 'CIMMYT Yellow' generated the lowest yield (Table 2). The results of this investigation are consistent with those of Hussain *et al*. (2019) and Khalil *et al*. (2011), who also reported substantial differences in yield because of environmental and genetic effect.

Thousand grains weight

At the 1% probability level, the analysis of variance for thousand-grain weight demonstrated a highly significant difference among all genotypes (Table 1). The genotype 'CIMMYT Yellow' had the highest weight, 331.40 g (Table 2), indicating a higher average weight for a thousand grains. In comparison, the genotype 'Eidhi' had the lowest weight at 305.00 g, reflecting a relatively lower average weight for 1,000 grains. The findings of this study are consistent with those of Ali *et al*. (2022), who also noted considerable variations in thousand-grain weight. The variation in 1000-grains is normally because of wide genetic base of the tested population (Hidayat *et al*., 2006).

Conclusions and Recommendations

The yellow maize genotypes varied across several morphological and yield-related parameters. Significant variations were observed in days to tasseling, days to silking, anthesis-silking interval, plant height, leaf area, grains per ear, 1000-grain weight, and grain yield among the genotypes, while no significant differences were found in days to maturity. The genotype 'Bamkhel-2' demonstrated superiority in terms of leaf area, plant height, grains per ear, and yield compared to the other genotypes examined. These findings suggest that 'Bamkhel-2' has favorable characteristics for crop productivity and may be a promising candidate for further agricultural applications. The 'Saleem Khan-2' genotype shows a genetic advantage with superior performance in days to silking and days to tasseling. This shorter duration for these processes can lead to increased yield potential and better adaptation to environmental conditions.

The genotype 'Bamkhel-2' was found to be superior in terms of key traits such as leaf area, plant height, number of grains per ear, and overall yield. This genotype has the potential to increase crop productivity and is suitable for cultivation. In contrast, the 'Saleem Khan-2' genotype has a shorter silking and tasseling period, making it suitable for regions with early cropping seasons as it adapts well to these conditions. Regular evaluation of genotypes under diverse conditions is essential to ensure consistent and stable results. Additionally, farmers need proper training and support in planting timing, soil management, and pest and disease control to fully benefit from high-performance maize.

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Novelty Statement

Hybrids considered in the study are elite candidate and are never evaluated earlier for growth and development traits under the agroclimatic conditions of Swabi and adjacent regions.

Author's Contribution

Farhan Anjum: Conceptualization, investigation, writing-original draft, writing-review and editing
Sheraz Ahmed Khan: Conceptualization, formal analysis, investigation, supervision.
Raees Muhammad: Data curation, resources, validation
Yousaf Jamal and Durrishahwar: Data curation, formal analysis, resources, visualization.
Jawad Ali Shah: Formal analysis, resources, validation.
Hidayat Ullah: Supervision, validation, writing-review and editing.

Conflict of interest
The authors have declared no conflict of interest.

References

Ali, A., M. Adnan, A. Abbas, M.A. Javed, M.E. Safdar, M. Asif, M. Imran, T. Iqbal, F.U. Rehman and R. Ahmad. 2020. Comparative performance of various maize (*Zea mays* L.) cultivars for yield and related attributes under semi-arid environment. Agric. Biol. Res., 36(4): 63-66.

Ali, M., M. Ahsan, M.Z. Akram and S. Nazeer. 2022. Evaluation of various agro-morphological and genetic parameters of single cross doubled haploid maize hybrids. Sarhad J. Agric., 38(5): 1-11. https://doi.org/10.17582/journal.sja/2022/38.5.1.11

Ali, W., M. Ali, Z. Ahmad, J. Iqbal, S. Anwar and M.K.A. Kamal. 2018. Influence of sowing dates on varying maize (*Zea mays* L.) varieties grown under agro-climatic condition of Peshawar, Pakistan. Eur. J. Exp. Biol., 8(6): 36. https://doi.org/10.21767/2248-9215.100077

Dohlman, E., J. Hansen and D. Boussios 2022. USDA agricultural projections to 2031, USDA miscellaneous 323859, United States Department of Agriculture.

FAO, 2019. FAO stat 2017. accessed at http://www.fao.org/faostat/en/#data/QC.

GOP, 2022. Ministry of planning and special initiatives. Pakistan statistical yearbook 2022. Pakistan Bureau of Statistics, Islamabad, Pakistan. https://www.pbs.gov.pk/sites/default/files/other/yearbooks/Pakistan_Statistical_Year_Book_2022.pdf

Hidayat, U., I.H. Khalil, G. Hassan, I. Ullah and Hidayat-ur-Rahman. 2006. Performance of local and exotic inbred lines of maize under agro-ecological conditions of Peshawar. Sarhad J. Agric., 22(3): 409-414.

Hussain, I., S. Naveed, S. Shah, A.U. Rahman, H. Zada, I. Ullah, A.A. Khan and S. Uddin. 2016. Growth and yield of maize hybrids as effected by different sowing dates in Swat Pakistan. Pure Appl. Biol., 5(1): 114-120. https://doi.org/10.19045/bspab.2016.50015

Hussain, M., A. Latif, W. Hassan, S. Farooq, S. Hussain, S. Ahmad and A. Nawaz. 2019. Maize hybrids with well-developed root system perform better under deficit supplemental irrigation. Soil Environ., 38(2): 203-213. https://doi.org/10.25252/SE/19/61578

Khalil, I.A., H. Rahman, N.U. Rehman, M. Arif, I.H. Khalil, M. Iqbal, H. Ullah, K. Afridi, M. Sajjad and M. Ishaq. 2011. Evaluation of maize hybrids for grain yield stability in North-West of Pakistan. Sarhad J. Agric., 27(2): 213-218.

Khan, A.S., H. Ullah, D. Shahwar, S. Fahad, N. Khan, M. Yasir, F. Wahid, M. Adnan and M. Noor. 2018. Heritability and correlation analysis of morphological and yield traits in Maize. J. Plant Biol. Crop Res., 2: 1008.

Khan, F., S. Khan, S. Fahad, S. Faisal, S. Hussain, S. Ali and A. Ali. 2014. Effect of different levels of nitrogen and phosphorus on the phenology and yield of maize varieties. Am. J. Plant Sci., 5(17): 2582-2590. https://doi.org/10.4236/ajps.2014.517272

Mtyobile, M., 2021. Evaluation of the yield performance of maize cultivars (*Zea mays* L.) in a semi-arid region of the Eastern Cape province, South Africa. Int. J. Agric. Sci. Food Tech., 7(3): 327-330. https://doi.org/10.17352/2455-815X.000126

Muhammad, B., M. Adnan, F. Munsif, S. Fahad, M. Saeed, F. Wahid, M. Arif, J. Amanullah, D. Wang, S. Saud and M. Noor. 2019. Substituting urea by organic wastes for improving maize yield in alkaline soil. J. Plant Nutr., 42(19): 2423-2434. https://doi.org/10.1080/01904167.2019.1659344

Noor, M., H. Rahman, M. Iqbal, Durrishahwar, S.M.A. Shah and I. Ullah. 2010. Evaluation of maize half sib families for maturity and grain yield attributes. Sarhad J. Agric., 26(4): 545-549.

Qureshi, S.U.R. and M.K. Khalil. 2019. Assessment of heritability and genetic variability for morphological and yield contributing traits in open pollinated maize varieties. Am. J. BioSci., 7(6): 99-103. https://doi.org/10.11648/j.ajbio.20190706.13

Sardar, S.H., Y. Jamal, I. Ullah, A. Basir, H. Ullah, M. Alam and Ikramullah. 2022. Evaluation of elite candidate maize hybrids for growth and development under the agroclimatic conditions of Peshawar valley. Sarhad J. Agric., 39: 236-241. https://doi.org/10.17582/journal.sja/2023/39.1.236.241

Steel, R.G.D. and J.H. Torri. 1980. Principal and procedures of statistics. New York: McGraw HillBook Co.

Ullah, I., I.H. Khalil, H. Ullah and J. Khan. 2005. Comparative performance of F_1 maize hybrids across seasons. Sarhad J. Agric., 21(3): 395-402.

Ullah, Z., W.U. Khan, M. Alam, H. Ullah and A. Bahadar. 2021. Development of S1 inbred lines and estimation of inbreeding depression in two maize (*Zea mays* L.) populations. Pure Appl. Biol., 4(4): 575-583. https://doi.org/10.19045/bspab.2015.44017

Yousaf, M.I., M.H. Bhattı, A. Ghanı, A. Shehzad, A. Hussaın, R. Shahzad, M.A. Hafeez, M. Abbas, M.U. Khalıd and N. Akhter. 2021. Variations among maize (*Zea mays* L.) hybrids in response to heat stress: Hybrids selection criteria. Turk. J. Field Crops, 26(1): 8-17. https://doi.org/10.17557/tjfc.943458