Evaluation of Single Cross Hybrids of Maize (*Zea mays* L.) in Winter Season at Rampur, Chitwan, Nepal

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Abstract— *A study was conducted to identify high-yielding single-cross maize hybrids. A total of 26 single-cross maize hybrids along with four checks were evaluated at the research field of the National Maize Research Program, Rampur, Chitwan, from November 2023 to May 2024. The experiment was laid out in an alpha-lattice design with two replications and six blocks per replication. Data for 14 agro-morphological and yield-related traits were recorded. Analysis of variance revealed significant differences in all traits, with heritability ranging from moderate (0.43-0.57) to high (0.64-0.87). ZH22668 (11.33 t ha⁻¹) was the highest-yielding hybrid, while ZH22741 (9.94 t ha⁻¹), ZH22712 (9.61 t ha⁻¹), ZH2182 (9.45 t ha⁻¹), ZH20379 (9.38 t ha⁻¹), and ZH22691 (9.37 t ha⁻¹) produced yields comparable to the commercial checks CP 808 (9.36 t ha⁻¹) and Sultan (9.33 t ha⁻¹). ZH22668, ZH22741, and ZH22712 showed a yield advantage of 2.62-21.04% over CP 808 and 26.38-49.11% over internal check CAH153. Therefore, ZH22668, ZH22741, and ZH22712 are promising hybrids for further evaluation in the inner-terai region of Nepal.*

Keywords— *Maize hybrids, Grain yield, Agro-morphological traits, Yield advantage, Winter season.*

I. INTRODUCTION

Maize (*Zea mays* L., 2n=2x=20) is a highly versatile and widely adaptable crop, recognized as one of the world's leading cereals with diverse types. It is also known as "queen of cereals" as it has the highest productivity compared to other cereals (Das et al., 2018). It has a wider range of uses as a 4F crop, i.e., food, feed, fuel, fodder, and industrial raw materials (Shikha et al., 2020). Globally, maize ranks second among cereals in terms of area under cultivation, occupying approximately 208 million hectares, and first in total production, with an annual output of about 1,241 million tons, with average productivity of 5.96 t ha⁻¹ (FAOSTAT, 2023). In Nepal, maize occupies 0.94 million hectares of land with 2.97 million tons production and 3.16 t ha⁻¹ productivity, contributing 7.61% to the total national AGDP (MoALD, 2023).

Single-cross hybrids are the first filial generation (F₁) obtained from the crossing of two inbred lines (Makavu, 2018) and generally produce higher grain yield compared to double and triple cross hybrids. The National Maize Research Program (NMRP) focuses on maize breeding and hybrid development, having released ten maize hybrids to date (MoALD, 2023). However, Nepal still imports substantial quantities of hybrid maize seed (3655.8 tons) and maize grain (435217.7 tons) annually (MoALD, 2023), indicating a need for developing competitive domestic hybrids.

Over the last 10 years, the demand for maize grain has increased by 5% annually (Adhikari et al., 2024), with the poultry feed industry alone requiring 391,538 tons of yellow maize annually (Koirala et al., 2020). Currently, domestic production fulfills only 25% of this demand. Hybrids are more responsive to irrigation and fertilizer, yielding 20-30% higher than open-pollinated varieties (Thapa et al., 2022). However, only 20% of Nepal's maize area is covered by hybrids, with 75% still under open-pollinated varieties (Yadav et al., 2023).

Winter maize production in the Terai region and river basins offers potential for increasing national maize production. Therefore, this study was conducted to evaluate single-cross maize hybrids to identify high-yielding genotypes suitable for winter cultivation in the inner-terai region of Nepal.

II.   MATERIALS AND METHODS

2.1   Experimental site:

The field experiment was conducted during the winter season from November 24, 2023 to May 7, 2024 at the research field of NMRP, Rampur, Chitwan, Nepal (27°40ʹ N, 84°19ʹ E, 228 m altitude).

2.2   Climatic conditions:

Monthly mean climatic data recorded during the growing period showed a maximum temperature of 39.07°C and minimum of 8.11°C. Maximum relative humidity (97.33%) occurred in December and minimum (55.02%) in April. Rainfall was recorded only in March (24.40 mm).
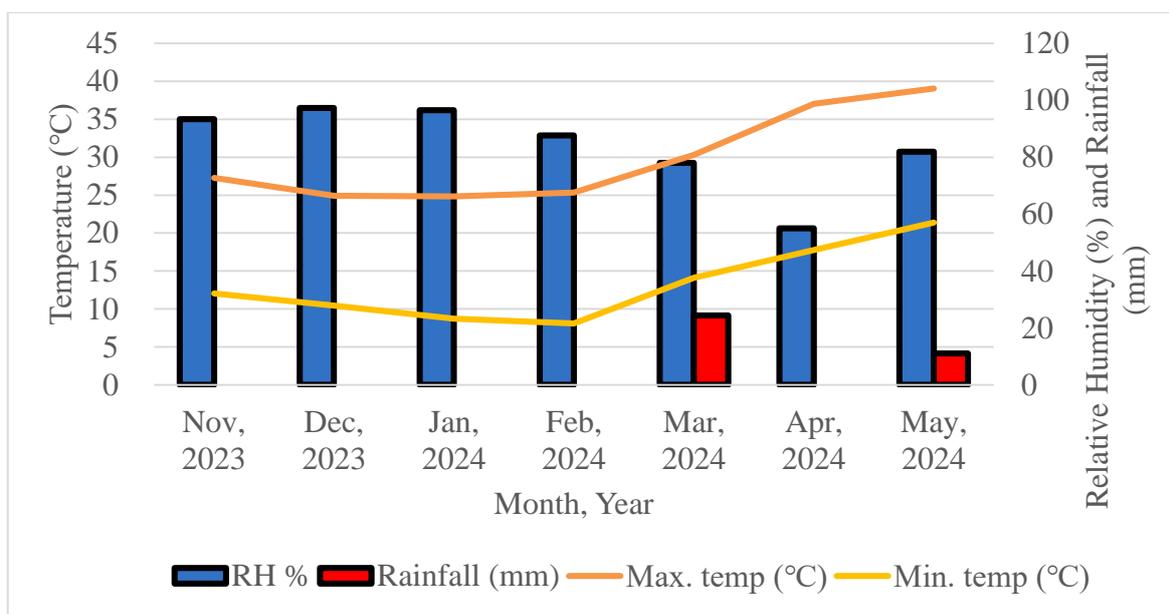
FIGURE 1: Climatic conditions during the research period at Rampur Chitwan, Nepal, 2023/24 (Source: NMRP, Rampur, Chitwan)

2.3   Plant Materials:

In this research, a total of thirty genotypes were used, comprising twenty-six experimental single-cross hybrids, two commercial checks (CP 808 and Sultan), one local check (Rampur Hybrid-10), and one internal check (CAH153). The single-cross hybrids and CAH153 were CIMMYT materials, CP 808 and Sultan were from multinational companies, and Rampur Hybrid-10 was from the National Maize Research Program (NMRP). All plant materials were obtained from NMRP. The complete list is presented in Table 1.

TABLE 1
LIST OF MAIZE HYBRIDS EVALUATED IN THE STUDY

Entry No.	Hybrid Name	Entry No.	Hybrid Name
1	ZH22707	16	ZH22742
2	ZH22700	17	ZH20379
3	ZH22713	18	ZH22724
4	ZH22697	19	ZH22740
5	ZH22702	20	ZH22741
6	ZH22668	21	ZH22780
7	ZH22691	22	ZH2157
8	ZH191006	23	ZH2182
9	ZH20272	24	ZH22727
10	ZH22712	25	ZH22731
11	ZH19770	26	ZH22744
12	ZH191003	27	CAH153 (Internal check)
13	ZH22698	28	CP 808 (Commercial check 1)
14	ZH22705	29	Sultan (Commercial check 2)
15	ZH22709	30	Rampur Hybrid-10 (Local check)

2.4   Experimental design and crop management:

The experiment was laid out in an alpha-lattice design with two replications. Each genotype was sown in two rows of 4 m length with spacing of 75 cm × 20 cm, giving a net plot area of 6 m². FYM at 10 t ha⁻¹ was applied during land preparation. Fertilizer was applied at 180:60:40 kg ha⁻¹ of $N:P_2O_5:K_2O$, with half N and full P and K as basal dose, and remaining N split-applied at knee height and pre-tasseling stages. Pre-emergence herbicide (Atrazine 50% WP + Pendimethalin 30% EC) was applied two days after sowing. Irrigation was applied at critical growth stages, and Spinosad 45 SC was sprayed at 30 DAS for fall armyworm control.

2.5   Data Recorded:

Data on agro-morphological and yield-attributing traits were recorded. Flowering traits (days to 50% anthesis and days to 50% silking), stand count (number of plants and number of ears per plot), and ear aspect were recorded on a plot basis. Plant height (cm), ear height (cm), number of leaves above the uppermost ear, cob length (cm), cob diameter (cm), number of kernel rows per ear, number of kernels per row, and thousand kernel weight (g) were recorded from five randomly selected competitive plants per plot.

The anthesis-silking interval (ASI, in days) was calculated as:

ASI = Days to 50% silking – Days to 50% anthesis   (1)

Ear position was calculated as:

Ear Position = Ear Height (cm) / Plant Height (cm)   (2)

Prolificacy was calculated as:

Prolificacy = (Number of ears per hectare) / (Number of plants per hectare)   (3)

Ear aspect was recorded by visual rating on a scale of 1 to 5, where **1 = clean, uniform, large, and well-filled ear; 3 = average; and 5 = rotten, variable, small, and partially filled ear** (Rai et al., 2022).

A seed counting machine was used to count five hundred grains, and their weight was measured. The weight was adjusted to a 12.5% moisture content using the following formula (Yadav et al., 2024):

Adjusted 1000-kernel weight (g) = [(100 – Grain moisture content %) / (100 – 12.5)] × (2 × 500 kernel weight)   (4)

Grain yield (t ha^{-1}) adjusted to 12.5% moisture content was calculated from the fresh ear weight using the formula described by Carangal et al. (1971):

Grain yield (t ha^{-1}) = [FW × (100 – HMC) × S × 10] / [(100 – DMC) × NAH]   (5)

Where: FW = field weight (kg); HMC = moisture content in grains at harvest (%); DMC = desired moisture content (12.5%); S = shelling coefficient (0.8); and NAH = net area harvested per plot (6 m²).

2.6   Statistical Analysis:

Data entry and processing were performed using MS Excel 365. Analysis of variance (ANOVA) for the alpha-lattice design and mean comparisons were conducted using R-Studio (Version 4.5.1). Analysis of covariance (ANCOVA) was performed using MINITAB to adjust grain yield for variations in plant population, using the number of plants per hectare as a covariate.

Broad-sense heritability (h²bs) was estimated on an entry-mean basis using the formula of Justin and Fehr (1988):

h²bs = Vg / Vp   (6)

Where:

Genotypic variance (Vg) = (MSSgenotype – MSSerror) / r; Phenotypic variance (Vp) = Vg + Ve; and Ve = MSSerror

(where MSS is Mean Sum of Squares and r is the number of replications).

The broad-sense heritability was categorized as **low (0.00–0.30), moderate (0.30–0.60), and high (>0.60)** as suggested by Johnson et al. (1955).

The percentage yield advantage of the test hybrids over the trial mean and check varieties was calculated using the formula of Heisey et al. (1998):

% Yield Advantage over Check = [(Yield of Hybrid – Yield of Check) / Yield of Check] × 100   (7)

% Yield Advantage over Trial Mean = [(Yield of Hybrid – Trial Mean Yield) / Trial Mean Yield] × 100   (8)

III.   RESULTS AND DISCUSSION

3.1   Mean Performance of Agro-Morphological, Yield, and Yield-Related Traits:

The analysis of variance revealed highly significant differences (p<0.01) among the thirty maize genotypes for all observed traits (Tables 2, 3, and 4), indicating the presence of substantial genetic variability. This variability is essential for effective selection and hybrid development (Belay, 2018).

TABLE 2

FLOWERING AND PLANT HEIGHT TRAITS OF THIRTY MAIZE HYBRIDS EVALUATED DURING THE WINTER SEASON AT RAMPUR, CHITWAN, NEPAL

Genotypes	AD	SD	ASI	PH (cm)	EH (cm)	EP
CAH153	108	110	2	185	74	0.4
CP 808	111	112	1	175	84	0.48
Sultan	106	108	2	206	90	0.43
Rampur Hybrid-10	109	110	1	175	71	0.41
ZH191003	107	110	3	177	76	0.43
ZH191006	111	112	1	176	97	0.55
ZH19770	106	110	3.5	192	83	0.43
ZH20272	109	111	2	204	115	0.57
ZH20379	108	108	0	193	94	0.49
ZH2157	108	110	2	207	86	0.42
ZH2182	106	108	2	163	84	0.52
ZH22668	108	109	1	193	91	0.47
ZH22691	108	110	1.5	177	97	0.55
ZH22697	106	108	2	185	86	0.46
ZH22698	106	107	1	187	78	0.42
ZH22700	109	112	3.5	198	90	0.45
ZH22702	109	111	2	164	76	0.46
ZH22705	107	107	0	183	83	0.45
ZH22707	107	109	2	173	84	0.48
ZH22709	106	108	2	166	70	0.42
ZH22712	112	113	1	189	98	0.52
ZH22713	109	112	3.5	182	86	0.47
ZH22724	107	110	3	172	73	0.43
ZH22727	107	110	2.5	193	80	0.42
ZH22731	107	109	1.5	200	99	0.49
ZH22740	110	111	1	208	99	0.48
ZH22741	107	109	2	198	100	0.5
ZH22742	107	109	2.5	188	91	0.48
ZH22744	108	110	2	181	79	0.44
ZH22780	103	105	2	137	61	0.44
Mean	108	109	1.8	184	86	0.46
SEm (±)	1.01	0.1	0.24	5.98	4.53	0.02
LSD (0.05)	2.99	3	0.72	17.7	13.4	0.06
CV (%)	1.33	1.29	18.66	4.6	7.48	6.35
F test	**	**	**	**	**	**
h²bs	0.49	0.49	0.57	0.73	0.72	0.64

*Note: **Significant at 1% level of probability; SEm, standard error of mean; LSD, least significant difference; CV, coefficient of variation; h²bs, broad-sense heritability; AD, days to 50% anthesis; SD, days to 50% silking; ASI, anthesis-silking interval; PH, plant height; EH, ear height; EP, ear position.*

TABLE 3

PLANT POPULATION, PROLIFICACY, EAR ASPECT, AND LEAVES ABOVE THE UPPERMOST EAR OF THIRTY
MAIZE HYBRIDS EVALUATED DURING THE WINTER SEASON AT RAMPUR, CHITWAN, NEPAL

Genotypes	NOP (ha⁻¹)	NOE (ha⁻¹)	PROF	EA	NLAE
CAH153	55834	55834	1	2.3	6
CP 808	65000	65667	1.01	1.3	6.5
Sultan	58334	72500	1.25	2.8	6
Rampur Hybrid-10	7500	11667	1.36	3.3	6
ZH191003	60834	60834	1	3	6
ZH191006	51667	54167	1.05	3	5
ZH19770	55834	91667	1.65	3.5	6
ZH20272	61667	96667	1.59	3.3	4
ZH20379	55000	80833	1.47	3.3	6
ZH2157	64167	90000	1.4	3	6
ZH2182	51667	51667	1	1.3	5.5
ZH22668	48334	88333	1.89	3	6
ZH22691	50000	69167	1.4	2	6
ZH22697	65834	70834	1.08	3.3	5.5
ZH22698	56667	58333	1.03	2.5	6
ZH22700	50834	59167	1.17	2.3	5
ZH22702	46667	50000	1.07	1.8	5
ZH22705	57500	67500	1.17	3.5	6
ZH22707	50000	85834	1.71	3.5	5
ZH22709	55000	59167	1.08	2	6
ZH22712	66667	86667	1.3	2.3	5
ZH22713	63334	94167	1.48	3	5.5
ZH22724	56667	60000	1.06	2.5	6
ZH22727	63334	60833	0.96	2.5	6
ZH22731	41667	45000	1.09	3.3	6
ZH22740	60000	69167	1.15	3	5
ZH22741	64167	73334	1.14	1.5	5
ZH22742	57500	90833	1.58	2.5	5
ZH22744	60000	65000	1.08	2	6
ZH22780	46667	58333	1.25	3.5	5
Mean	54945	68106	1.25	2.7	5.6
SEm (±)	4708	7051	0.1	0.38	0.16
LSD (0.05)	13937	20872	0.29	1.11	0.48
CV (%)	12.12	14.64	11.25	20.06	4.15
F test	**	**	**	**	**
h²bs	0.69	0.74	0.73	0.53	0.83

*Note: **Significant at 1% level of probability; SEm, standard error of mean; LSD, least significant difference; CV, coefficient of variation; h²bs, broad-sense heritability; NOP, number of plants per hectare; NOE, number of ears per hectare; PROF, prolificacy (ears per plant); EA, ear aspect (1=best, 5=worst); NLAE, number of leaves above the uppermost ear.*

TABLE 4
YIELD AND YIELD-RELATED TRAITS OF THIRTY MAIZE HYBRIDS EVALUATED DURING THE WINTER SEASON AT RAMPUR, CHITWAN, NEPAL

Genotypes	CL (cm)	CD (cm)	NKRPE	NKPR	TKW (g)	GY (t ha⁻¹)
CAH153	15.2	4.71	14	25.1	419	7.6
CP 808	17	5.34	18	31.8	404	9.36
Sultan	14.9	4.75	14	28.6	400	9.33
Rampur Hybrid-10	18	4.65	14	31.5	429	4.75
ZH191003	15.8	4.66	14	27.2	471	7.92
ZH191006	16.2	4.67	12	30.7	443	7.38
ZH19770	13.7	4.58	14	29.3	336	7.35
ZH20272	15.2	4.4	12	28	404	8.53
ZH20379	17.9	4.21	10	28.5	454	9.38
ZH2157	13.3	4.9	14	28.1	378	9.24
ZH2182	17.1	5.19	16	34.7	295	9.45
ZH22668	15.3	4.89	14	29.4	372	11.33
ZH22691	15.7	5.14	14	31.1	364	9.37
ZH22697	14.4	4.77	14	30.1	386	7.65
ZH22698	16.4	4.57	14	28.6	435	8.65
ZH22700	16.6	4.67	14	32.5	435	9.33
ZH22702	17	4.83	14	33.2	417	8
ZH22705	15.6	4.11	10	26.7	449	7.11
ZH22707	14.4	4.35	12	30	342	8.22
ZH22709	16.9	4.64	16	28.4	437	8.87
ZH22712	15.4	5.17	14	33.9	368	9.61
ZH22713	15.4	5	16	30.9	314	8.22
ZH22724	16	4.57	14	28	422	8.26
ZH22727	16.7	4.68	14	29.5	446	8.53
ZH22731	17.5	4.57	14	30.3	404	6.44
ZH22740	17.1	4.53	14	29.9	462	8.1
ZH22741	18.2	4.8	14	31.7	439	9.94
ZH22742	16.4	4.45	14	33.4	308	8.8
ZH22744	17.9	4.62	14	29.6	430	8.05
ZH22780	13.1	4.64	14	24.6	372	6.64
Mean	16	4.7	14	29.8	401	8.38
SEm (±)	0.73	0.07	0.8	1.53	29.7	0.66
LSD (0.05)	2.15	0.22	2.38	4.54	87.9	1.97
CV (%)	6.43	2.22	8.5	7.26	10.47	11.21
F test	**	**	**	*	*	**
h²bs	0.56	0.87	0.53	0.43	0.43	0.76

*Note: **, *, Significant at 1% and 5% level of probability, respectively; SEm, standard error of mean; LSD, least significant difference; CV, coefficient of variation; h²bs, broad-sense heritability; CL, cob length; CD, cob diameter; NKRPE, number of kernel rows per ear; NKPR, number of kernels per row; TKW, thousand kernel weight; GY, grain yield.*

3.1.1   Flowering and Plant Architecture Traits:

There were highly significant differences for days to 50% anthesis and silking, which aligns with findings by Khan et al. (2019) and Rai et al. (2022). Days to 50% anthesis ranged from 103 (ZH22780) to 112 (ZH22712), and silking from 105 (ZH22780) to 113 days (ZH22712). These traits determine the maturity period, a crucial parameter for breeding (Ullah et al., 2017).

The anthesis-silking interval (ASI) also showed significant variation (0 to 3.5 days, with a mean of 1.8 days), in agreement with Adhikari et al. (2024) and Rai et al. (2022). A shorter ASI (0–3 days) indicates better synchronization between pollen shedding and silk emergence, which is vital for successful pollination under potential abiotic stresses (Ngugi et al., 2013). In this study, genotypes ZH20379 and ZH22705 exhibited a 0-day ASI, suggesting excellent synchrony.

Significant differences were observed for plant height, ear height, and ear position (Table 2), consistent with reports by Ogunniyan and Olakojo (2014) and Rai et al. (2022). Plant height ranged from 137 cm (ZH22780) to 208 cm (ZH22740), and ear height from 61 cm (ZH22780) to 115 cm (ZH20272). Ear position, calculated as the ratio of ear to plant height, ranged from 0.40 to 0.57. These architectural traits are critical for lodging resistance and yield optimization (Liu et al., 2021). An ear position around 0.50 ± 0.03 is generally considered optimal, balancing lodging risk with ease of harvest (Koirala et al., 2020; Zsubori et al., 2002).

3.1.2   Stand Count, Prolificacy, and Ear Quality:

The number of plants per hectare, number of ears per hectare, and prolificacy (ears per plant) showed highly significant differences (Table 3), supporting findings by Neupane et al. (2020). Plant population ranged from 7,500 to 66,667 plants ha^{-1}. Prolificacy ranged from 0.96 (ZH22727) to 1.89 (ZH22668). A value greater than 1.3 indicates a double-cobbed plant. Five hybrids (ZH22668, ZH22712, ZH20379, ZH22691, and ZH2157) showed prolificacy >1.3, a trait that can be crucial for higher productivity (Zsubori et al., 2002).

Ear aspect, a key visual quality trait, varied significantly among genotypes (1.3 to 3.5), with lower scores being desirable. This aligns with findings by Neupane et al. (2020). The number of leaves above the uppermost ear also varied significantly (4.0 to 6.5), which can influence canopy architecture and photosynthetic efficiency (Li et al., 2016).

3.1.3   Yield Components and Final Grain Yield:

Cob characteristics and yield components exhibited significant genetic variation (Table 4). Cob length ranged from 13.1 cm to 18.2 cm, and cob diameter from 4.11 cm to 5.34 cm. The number of kernel rows per ear varied from 10 to 18, and kernels per row from 24.6 to 34.7. These traits are direct yield determinants, and their significant variation is consistent with previous studies (Khan et al., 2019; Sesay et al., 2016).

Thousand kernel weight (TKW) ranged from 295 g to 471 g, showing significant but moderate differences. Grain yield, the primary trait of interest, showed highly significant differences, ranging from 4.75 t ha^{-1} (Rampur Hybrid-10) to 11.33 t ha^{-1} (ZH22668). The highest-yielding hybrid, ZH22668, significantly outperformed the best commercial check (CP 808, 9.36 t ha^{-1}). This significant variability for grain yield, a complex quantitative trait, is commonly reported (Belay, 2018; Rai et al., 2022).

3.2   Heritability Estimates:

Broad-sense heritability (h²bs) estimates varied from moderate to high (Tables 2-4). High heritability (>0.60) was observed for plant height (0.73), ear height (0.72), ear position (0.64), prolificacy (0.73), cob diameter (0.87), number of leaves above the ear (0.83), and grain yield (0.76). This suggests that phenotypic selection for these traits would be effective, as they are less influenced by the environment (Adhikari et al., 2024; Magar et al., 2021).

Moderate heritability (0.30–0.60) was recorded for days to anthesis (0.49) and silking (0.49), ASI (0.57), ear aspect (0.53), cob length (0.56), number of kernel rows per ear (0.53), number of kernels per row (0.43), and TKW (0.43). For these traits, selection should be exercised with caution, preferably across multiple environments, due to greater environmental influence (Rai et al., 2022).

3.3   Yield Advantage of Test Hybrids:

The grain yield advantage of the 26 test hybrids over the trial mean and check varieties is presented in Table 5. The trial mean yield was 8.38 t ha^{-1}. The hybrid **ZH22668** demonstrated a superior yield advantage of **21.07% over CP 808**, **21.46% over**

Sultan, and a remarkable **49.11% over the internal check CAH153**. **ZH22741** and **ZH22712** also showed substantial advantages of 6.19–6.53% over commercial checks and 26.38–30.78% over CAH153.

TABLE 5

GRAIN YIELD AND PERCENTAGE YIELD ADVANTAGE OF 26 TEST HYBRIDS OVER THE TRIAL MEAN AND CHECK VARIETIES

S.N.	Hybrids	GY (t ha⁻¹)	% Yield Advantage Over				
			Trial Mean	CP 808	Sultan	CAH153	Rampur Hybrid-10
1	ZH22668	11.33	35.23	21.07	21.46	49.11	138.57
2	ZH22741	9.94	18.6	6.19	6.53	30.78	109.24
3	ZH22712	9.61	14.62	2.62	2.95	26.38	102.21
4	ZH2182	9.45	12.78	0.97	1.3	24.36	98.97
5	ZH20379	9.38	11.89	0.17	0.49	23.37	97.39
6	ZH22691	9.37	11.77	0.06	0.39	23.24	97.18
7	ZH22700	9.33	11.31	-0.34	-0.02	22.74	96.38
8	ZH2157	9.24	10.26	-1.28	-0.96	21.58	94.53
9	ZH22709	8.87	5.8	-5.28	-4.97	16.66	86.65
10	ZH22742	8.8	4.99	-6	-5.7	15.76	85.22
11	ZH22698	8.65	3.2	-7.61	-7.31	13.79	82.06
12	ZH22727	8.53	1.75	-8.9	-8.61	12.2	79.52
13	ZH20272	8.53	1.74	-8.91	-8.62	12.18	79.49
14	ZH22724	8.26	-1.38	-11.71	-11.43	8.74	73.98
15	ZH22713	8.22	-1.91	-12.18	-11.9	8.16	73.05
16	ZH22707	8.22	-1.92	-12.19	-11.91	8.14	73.03
17	ZH22740	8.1	-3.34	-13.46	-13.18	6.58	70.53
18	ZH22744	8.05	-3.99	-14.04	-13.76	5.87	69.39
19	ZH22702	8	-4.56	-14.55	-14.28	5.24	68.38
20	ZH191003	7.92	-5.47	-15.36	-15.09	4.24	66.78
21	ZH22697	7.65	-8.75	-18.3	-18.04	0.62	60.99
22	ZH191006	7.38	-11.98	-21.2	-20.94	-2.95	55.28
23	ZH19770	7.35	-12.3	-21.49	-21.23	-3.3	54.72
24	ZH22705	7.11	-15.14	-24.03	-23.78	-6.43	49.71
25	ZH22780	6.64	-20.74	-29.04	-28.81	-12.61	39.83
26	ZH22731	6.44	-23.15	-31.2	-30.98	-15.26	35.58

Note: Trial Mean = 8.38 t ha⁻¹; CP 808 = 9.36 t ha⁻¹; Sultan = 9.33 t ha⁻¹; CAH153 = 7.60 t ha⁻¹; Rampur Hybrid-10 = 4.75 t ha⁻¹. GY = Grain Yield.

Other hybrids like ZH2182, ZH20379, and ZH22691 yielded on par with the commercial checks but showed a 23–24% advantage over CAH153. The significant yield advantage of new hybrids over established checks, often ranging from 10–60%, highlights the continuous genetic gain achievable through breeding (Goshime et al., 2020). It is important to note that yield advantage is influenced by genotype, environment, and their interaction, underscoring the need for multi-environment testing to confirm the stability of these promising hybrids (Rezende et al., 2020)

IV.   CONCLUSION

The evaluated maize hybrids showed significant genetic variability in days to 50% anthesis and silking, anthesis-silking interval, plant and ear height, ear position, number of plants, number of ears, prolificacy, ear aspect, cob length, cob diameter, number of kernels per row, number of kernel rows per ear, thousand-kernel weight, and grain yield. Among studied hybrids ZH22668 showed significantly higher grain yield followed by ZH22741 and ZH22712 as compared to commercial checks CP

808 and all these genotypes showed significantly higher grain yield compared to internal check CAH153. Genotype ZH22668 showed 21.07% yield advantage over CP-808. Genotypes ZH22668, ZH22741, and ZH22712 showed 49.11%, 30.78%, and 26.38% yield advantage over internal check CAH153 respectively. Overall, the results suggest that ZH22668, ZH22741, and ZH22712 are promising hybrids, showing positive yield advantages across all checks with desirable traits, making them suitable candidates for further testing in multi-season and multi-location trials.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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