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EVALUATION OF PER SE PERFORMANCE FOR YIELD AND YIELD-ATTRIBUTING TRAITS IN MAIZE (*ZEA MAYS* L.)

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The present study aimed to evaluate the average performance of maize (*Zea mays* L.) parents and F₁ hybrids regarding growth, flowering, and yield-related traits. The goal was to identify superior genotypes for productivity and adaptation. The experiment took place during the *kharif* season of 2022 at the experimental field of the All India Coordinated Research Project (AICRP) on Maize, Odisha University of Agriculture and Technology (OUAT), Bhubaneswar. The experimental material included twenty-one inbred lines, four testers, eighty-four F₁ hybrids developed through a line × tester mating design, and four commercial hybrid checks. The genotypes were evaluated using a Randomized Block Design with three replications for twelve quantitative traits related to flowering, growth, yield, and yield components.

Analysis of variance showed highly significant differences among genotypes for all studied traits. This indicates the presence of substantial genetic variability. The comparison between parents and hybrids revealed significant differences for all characters, suggesting heterosis. The mean performance analysis indicated that F₁ hybrids, on average, showed earlier flowering, increased plant and ear height, better cob attributes, higher shelling percentage, and superior grain yield compared to parental lines. Grain yield among hybrids ranged from 4096.97 to 10098.60 kg ha⁻¹, with the hybrid CML 425-4 × LM 14 recording the highest yield. Several hybrids also outperformed the standard commercial checks, highlighting their potential for further evaluation.

The study underscores the importance of assessing mean performance for growth, flowering, and yield traits in maize. It also demonstrates the effectiveness of hybrid breeding in improving productivity. The superior hybrids identified here could be used in future maize improvement programs aimed at developing high-yielding and adaptable maize hybrids.

Key words: Maize, Mean performance, Line × tester, Growth traits, Flowering traits, Grain yield.

ABSTRACT

Introduction

Maize (*Zea mays* L.), commonly known as corn, is one of the most important cereal crops grown worldwide and holds a key position in global agriculture because of its high productivity and wide adaptability. It is the only species in the genus *Zea*, with a somatic chromosome number of $2n = 20$ and a genome size of about 2.3 gigabases. As a member of the Poaceae family, maize ranks third among cereal crops in India, following rice and wheat. Unlike most cereals, maize is a C₄ plant,

which means it has superior photosynthetic efficiency, high physiological productivity, and the greatest genetic yield potential among cereals (Manjunatha *et al.*, 2018). This distinction has earned it the title “Queen of Cereals.”

Maize displays remarkable adaptability to a wide range of agro-climatic conditions, such as variations in temperature, rainfall, altitude, and soil types. Its warm-season growth habit, tolerance to drought and pests, and relative insensitivity to photoperiod enable it to thrive in various environments and seasons (Ishfaq, 2011). This

adaptability has made maize an essential crop for food, feed, fodder, and industrial uses, including starch, ethanol, and biofuel production. Hence, it plays a vital role in food security and agro-based industries (Ali *et al.*, 2020).

Globally, the United States is the largest producer of maize. In India, maize production has consistently increased, placing the country among the top maize-producing nations. During 2022–23, maize production in India was estimated at 35.91 million tonnes, with exports reaching 3.45 million tonnes, reflecting its growing economic importance. The area under *rabi* maize cultivation has also expanded significantly, showing increased adoption of maize across seasons. States like Bihar, Maharashtra, Tamil Nadu, Telangana, and Andhra Pradesh are major contributors to national maize production. In Odisha, maize cultivation has grown substantially over the decades, with considerable improvements in area and productivity, illustrating the impact of better varieties and crop management practices.

Maize is a naturally cross-pollinated crop because of its monoecious and protandrous nature, which encourages allogamy and genetic diversity (Ramadan *et al.*, 2021). This characteristic has been effectively used in maize improvement programs, especially in hybrid breeding. The concept of heterosis in maize was first shown by George H. Shull in the late nineteenth century, leading to the commercialization of hybrid maize in the early twentieth century. The development of double-cross hybrids by Donald F. Jones marked a significant milestone in maize breeding, allowing large-scale production of high-yielding hybrids. Since then, ongoing advancements in breeding strategies have contributed to notable improvements in yield, quality, and adaptability of maize hybrids (Rajasekhar *et al.*, 2025).

The performance of any breeding population depends on its inherent genetic potential and its ability to combine effectively with other genotypes. In this context, heterosis and combining ability are key elements in developing superior maize hybrids. Key growth, flowering, and yield traits such as plant height, ear height, days to tasseling and silking, cob characteristics, kernel number, and grain yield are critical for productivity and adaptation. These traits are quantitatively inherited and influenced by complex interactions between genetic and environmental factors (Singh *et al.*, 2022).

Evaluating mean performance for growth, flowering, and yield traits is therefore a fundamental step in maize improvement programs. Such evaluation provides valuable insights into the agronomic potential of parents and hybrids, helps identify early-maturing and high-

yielding genotypes, and supports the selection of promising parental lines and cross combinations (Khan *et al.*, 2019). This study aims to evaluate the mean performance of maize genotypes for growth, flowering, and yield traits to assess genetic variability and identify superior genotypes with desirable trait combinations for improved productivity and adaptability under varying agro-climatic conditions (Hadi *et al.*, 2021).

Materials and Methods

The present investigation was carried out at the experimental field of the All India Coordinated Research Project (AICRP) on Maize, Odisha University of Agriculture and Technology (OUAT), Bhubaneswar, Odisha, during the kharif season of 2022. The experimental site is geographically located at 20°16' 03" N latitude and 85°47' 28" E longitude, with the Bay of Bengal situated approximately 63 km to the south of the location. The experimental field had uniform topography with good drainage and fertile sandy loam soil, which is well suited for maize cultivation. The climate of the region is humid subtropical, characterized by warm temperatures and adequate monsoonal rainfall, providing favorable conditions for maize growth and development during the kharif season.

The experimental material consisted of twenty-one maize inbred lines, four testers, and four commercial hybrid checks, all maintained by the AICRP on Maize, Bhubaneswar. The inbred lines were used as female parents, while the testers served as male parents for hybridization.

Testers

Four genetically diverse testers were used as male parents in the crossing programme. These testers were also maintained by AICRP on Maize, Bhubaneswar.

1. CML 451
2. CAL 1415
3. LM 13
4. LM 14

Standard Checks

Four widely cultivated commercial maize hybrids were included as standard checks for comparison.

Sr.	Name of Check	Source
1	NK 6240	Syngenta Pvt. Ltd.
2	BIO 9682	ShriramBioseed Genetics Pvt. Ltd.
3	DKC 9126	Bayer Crop Science Pvt. Ltd.
4	HISHELL	Bayer Crop Science Pvt. Ltd.

Hybridization was carried out using the line × tester

Table 1: Analysis of variance of parents and hybrids (F₁) for 12 characters in inbred tester cross of maize.

Sr.	Source	df	DA	DS	DDH	EH	PH	CY	S%	CL	CD	NKC	NKR	GY
1	Replication	2	11.581	7.379	9.746	40.872	45.111	0.54*	8.899	12.091**	0.002	0.494	13.849	35162244.417**
2	Treatments	108	28.729**	23.644**	27.117**	912.82**	3316.729**	1.856**	45.353**	15.314**	0.423**	5.339**	46.445**	5954237.83**
3	Parents	24	27.286**	26.126**	35.142**	274.913**	1374.211**	0.059	102.744**	12.211**	0.589**	3.784**	16.188	715892.237**
4	Parents vs Cross	1	1462.992**	905.569**	327.305**	73705.112**	239772.903**	36.409**	774.373**	588.669**	21.443**	170.93**	1952.974**	127797241.581**
5	Cross	83	11.866**	12.301**	21.18**	220.26**	1029.551**	1.96**	19.975	9.304**	0.121	3.793**	32.224**	6000952.173**
6	Lines	20	7.544	7.429	29.063	323.424*	1496.243*	2.202	21.789	15.392**	0.176*	2.624	32.117	7562060.429
7	Tester	3	10.73	12.015	4.201	363.009	345.433	4.534	42.857	30.274**	0.082	24.055**	187.307**	9607387.513
8	Lines × Tester	60	13.363**	13.94**	19.401**	178.734**	908.194**	1.75**	18.226	6.226**	0.105	3.17**	24.506**	5300260.987**
9	Error	216	4.294	4.5	8.481	48.691	51.712	0.134	20.337	1.999	0.099	1.285	11.695	196128.274

DA: Days to 50% Anthesis; DS: Days to 50% Silking; DDH: Days to 75% Dry Husk; EH: Ear Height (cm);

PH: Plant Height (cm); CY: Cob Yield (kg/plot); S%: Shelling %;

CL: Cob Length (cm); CD: Cob Diameter (cm); NKC: No. of Kernel Rows/ Cob; NKR: No. of Kernels/ Row; GY: Grain Yield (kg/ha)

**Significant at 1% probability. *Significant at 5% probability

mating design during the rabi season of 2021–22, following the method proposed by Kempthorne (1957). For this purpose, selected inbred lines and testers were grown in a hybridization block at the EB-II division of OUAT during the *kharif* season of 2021–22. To ensure synchronization of flowering and continuous availability of pollen, three staggered sowings were done at five-day intervals. Each inbred line was crossed with all four testers, resulting in the development of 84 F₁ hybrids.

Maize being a monoecious and cross-pollinated crop, controlled pollination techniques were employed. Tassels were bagged in the afternoon prior to pollen shedding using waterproof paper bags to avoid contamination, and pollen was collected the following morning. Silks were trimmed uniformly three to four days before pollination to ensure synchronized silk emergence, and ears were covered with butter paper bags before silk emergence to prevent unwanted pollination. Pollination was carried out between 8:00 a.m. and 11:00 a.m. by dusting collected pollen onto the silks, after which the ears were immediately rebagged. Each cross was properly labeled with details of the male and female parents and the date of pollination.

The 84 F₁ hybrids, along with twenty-five parents and four standard checks, were evaluated during the *kharif* season of 2022 in a Randomized Block Design (RBD) with three replications. The crop was planted at a spacing of 60 cm × 20 cm, and each plot consisted of two rows of four meters length, occupying an area of 4.8 m². All recommended agronomic practices were followed uniformly throughout the crop growth period to ensure proper crop establishment and development.

Observations Recorded

Observations were recorded on twelve quantitative traits. Flowering traits were recorded on a plot basis, while other traits were recorded on ten randomly selected plants or cobs per replication.

Observations Recorded Before Harvest

- Days to 50% anthesis
- Days to 50% silking
- Days to 75% dry husk
- Plant height (cm)
- Ear height (cm)

Observations Recorded After Harvest

- Cob yield (kg/plot)
- Cob length (cm)
- Cob diameter (cm)
- Number of kernel rows per cob

Table 2: Mean performance of parents for 12 characters in line × tester cross of maize.

Sr.	Characters	DA	DS	DDH	EH	PH	CY	SP	CL	CD	NKC	NKR	GY
Lines													
1	VL32389-3	56.33	57.67	86.33	62.9	117.4	3.09	72.37	10.07	3.24	9.96	17.15	4781.95
2	VL71370	51.67	55.33	85.67	66.67	148.43	2.94	83.59	10.07	3.36	12.15	16.87	5263.28
3	VL71493	54.33	55.67	86.67	62.1	157.4	2.82	70.17	15.43	3.14	11.83	19.01	4217.1
4	ZL114150-1	53.67	54.33	82.33	54.2	115.43	3.07	72.37	9.9	3.45	13.25	18.95	4747.58
5	VL20112	61.33	62.33	86.67	57.67	113.9	2.96	87.9	10.93	3.85	13.71	19.68	5425.05
6	VL171522	57.67	59.33	94.33	86.7	182.53	3.15	77.61	13.6	4.11	13.17	21.43	5123.11
7	ZL171310	55	56	85.67	75.83	132.97	3.05	86.36	12.3	4.14	12.25	20.96	5646.84
8	V25	60.33	61.33	91.67	66.1	149.93	3	75.45	12.33	3.88	12.82	19.05	4789.58
9	Umerkote-4-1	60.67	61.67	88.67	54.8	121.87	2.86	69.69	9.93	2.82	9.74	18.12	4242.47
10	VL20146	59.33	60.67	88.33	60.2	116.93	3.15	78	13.43	3.78	11.95	21.76	5183.46
11	VL70040	56	57.33	83.33	53.7	117.27	2.88	85.28	9.93	2.86	10.77	18.59	5182.83
12	VL18989	55.33	57	87.33	54.43	120.2	2.96	83.34	14.47	3.45	12.54	19.34	5225.59
13	CML425-4	52	52.67	91.67	73.2	157.17	2.95	76.05	14.07	4.27	12.04	24.78	4719.76
14	VL20160	54.33	56	88.33	66.93	140.87	3.19	85.11	14.97	4.24	10.72	23.21	5733.49
15	VL143906	55	56.33	84.67	79.63	136.37	2.94	76.92	14.33	3.47	13.87	17.76	4738.22
16	CML470-1	56	57.33	85.67	53.93	115.03	3.03	71.56	12.17	3.54	11.21	24.01	4605.28
17	VL71915	52.33	53.67	84.67	53.73	103.43	2.81	73.14	8.73	3.6	11.13	17.17	4367.5
18	VL18938	54	54.67	86.33	65.9	153.47	3.06	83.24	9	4.13	12.89	17.93	5395.84
19	VL175899	56.67	58	85.33	67.23	149.4	2.95	79.96	9.43	3.64	12.96	22.65	5015.3
20	VL18201	55.33	56.67	87.67	69.9	158.2	3.15	79.72	11.63	4.01	12.2	18.24	5264.29
21	VL18941	59.67	61	97.67	53.2	114.63	2.9	71.87	13.17	3.65	13	17.64	4363.58
Tester													
22	CML451	54.33	55.67	88.67	72.43	165.7	3.31	78.26	10.53	2.97	12.33	18.01	5450.59
23	CAL1415	51.67	53	87.67	72.2	169.43	2.78	77.94	9.47	3.97	12.33	16.65	4518.89
24	LM 13	53.67	54.67	90.33	67.6	136.17	3.14	79.34	11.83	2.97	12.55	18.05	5207.57
25	LM 14	61.33	62.67	90.33	80.55	152.5	2.76	65.76	12.17	3.97	13.98	17.87	3821.84
	Grand Mean	55.92	57.24	87.84	65.27	137.87	3.00	77.64	11.76	3.62	12.21	19.4	4921.24
	Min	51.67	52.67	82.33	53.2	103.43	2.76	65.76	8.73	2.82	9.74	16.65	3821.84
	Max	61.33	62.67	97.67	86.7	182.53	3.31	87.9	15.43	4.27	13.98	24.78	5733.49
	CV(%)	2.37	2.22	0.98	5.24	4.8	10.08	2.1	9.26	7.28	10.74	9.87	7.61
	SE(m)	0.76	0.73	0.5	1.97	3.82	0.17	0.94	0.62	0.15	0.75	1.1	216.5
DA: Days To 50% Anthesis; DS: Days To 50% Silking; DDH: Days To 75% Dry Husk; EH: Ear Height (cm); PH: Plant Height (cm); CY: Cob Yield (kg/ plot); SP: Shelling percentage (%); CL: Cob Length (cm); CD: Cob Diameter (cm); NKC: No Of Kernel Rows/ Cob; NKR: No Of Kernels/ Row; GY: Grain Yield (kg/ha)													

- Number of kernels per row
- Shelling percentage (%)
- Grain yield (kg/ha) adjusted to 15% moisture content

The collected data for all quantitative traits were subjected to statistical analysis using analysis of variance (ANOVA) appropriate for a line × tester design.

Results and discussion

Analysis of Variance

The analysis of variance revealed highly significant (Table 2), differences among genotypes for all the twelve characters studied, including parents, hybrids, and the comparison between parents and hybrids (Table 1). The

presence of significant variability among parental lines indicates the existence of substantial genetic diversity in the experimental material, which is essential for effective hybrid breeding. Furthermore, the significant differences observed between parents and hybrids for all traits clearly suggest the manifestation of heterosis, indicating that the F_1 hybrids, on average, outperformed their parents for yield and yield-related characters similar as Patel *et al.*, 2019 and Ramadan *et al.*, 2021).

Mean Performance

The mean performance of 25 parents (21 lines and 4 testers), 84 F_1 hybrids, and four standard checks for twelve quantitative traits is presented in Table 1, Table 2 and Table 3 respectively, revealing considerable variation

Table 3: Mean performance of crosses for 12 characters in line × tester cross of maize.

Sr.	Characters	DA	DS	DDH	FH	PH	CY	SP	CL	CD	NKC	NKR	GY
F₁ Hybrids													
1	VL32389-3xCML451	51.67	53.67	86.67	91	186.67	3.93	86.88	16.33	4.26	16.23	26.62	7046
2	VL32389-3xCAL1415	50.33	53.67	84.67	120.67	228.67	3.53	85.35	18.17	3.97	13.17	25.75	6258.47
3	VL32389-3xLM13	52.33	54	87.33	99.67	212.67	3.07	80.76	13.53	4.34	11.79	27.39	4809.08
4	VL32389-3xLM14	49	51.33	84.33	116.33	229	2.83	78.19	18.5	4.42	12.69	27.95	4550.6
5	VL71370xCML451	51.33	54	86.33	114.33	231.33	2.6	82.13	15.47	4.4	14.88	24.58	4437.77
6	VL71370xCAL1415	48.67	50.67	85	115.67	221	2.67	82.88	13.43	4.06	12.52	22.49	4517.09
7	VL71370xLM13	53.33	55.33	88.33	114	225	4.4	76.45	13.67	4.01	15.89	24.46	6958.24
8	VL71370xLM14	52.67	55.33	87.67	113.67	226.33	3.5	82.34	17.67	4.08	14.91	25.44	6008.46
9	VL71493xCML451	50	52.33	84.67	86.67	187	4.63	82.15	15.5	4.34	14.66	27.16	7808.68
10	VL71493xCAL1415	53.33	55.67	88.33	105.33	210	2.73	81.4	14.57	4.08	12.98	24.04	4557.9
11	VL71493xLM13	48.67	51.33	83.67	102.33	217	2.77	79.26	14.67	4.22	13.25	24.54	4490.45
12	VL71493xLM14	49.33	51.67	84	99.67	197.33	3.07	77.61	14.05	4.3	15.8	22.58	4634.68
13	ZL114150-1xCML451	52	54	86.67	86	177.33	3.47	82.6	14.5	4.45	15.42	26.11	5522.85
14	ZL114150-1xCAL1415	51.67	54.67	86	99.67	196	3.17	87.81	12.07	4.2	14.41	18.86	5762.97
15	ZL114150-1xLM13	52	54.67	86.67	100.67	197.33	3.43	79.69	14.53	4.32	12.68	22.62	5220.17
16	ZL114150-1xLM14	52.67	55	87.67	103.67	192	3.9	79.39	14.53	4.58	15.83	28.11	6435.1
17	VL20112xCML451	55	57.33	87	103.33	188.67	3.53	82.58	15.6	4.38	14.77	25.25	5660.83
18	VL20112xCAL1415	51.67	53.67	86.67	105.33	207.67	3.67	80.21	14.17	4.6	13.21	25.99	6059.57
19	VL20112xLM13	51	53	86	101.67	210	2.63	79.41	16	4.37	14.32	26.64	4332.29
20	VL20112xLM14	49.67	52	84.67	101.33	182.33	3.7	80.55	14.43	4.43	14.8	28.03	6195.25
21	VL171522xCML451	51.67	54.33	86.67	106.67	208.67	4.27	82.24	15.23	4.02	14.27	29.23	7219.33
22	VL171522xCAL1415	49	51.33	84.67	98.33	164	4.1	84.88	17.2	4.12	13.44	30.05	7152.12
23	VL171522xLM13	50.33	52.67	85.33	97.67	180.33	4.47	78.01	13.1	4.53	12.32	20.24	7182.3
24	VL171522xLM14	54	56.67	89	106.67	222.67	4.83	76.56	17.5	4.27	15.31	29.47	7599.24
25	ZL171310xCML451	54.33	57	77.67	87	178	3.47	80.73	16.43	4.06	14.45	29.58	5915.77
26	ZL171310xCAL1415	49.33	51.67	84.33	110.33	211	5.03	85.22	18.63	4.06	15.42	23.4	8785.39
27	ZL171310xLM13	49	51.67	84	97.33	206	4.2	79.47	16.3	3.92	12.99	25.15	7071.39
28	ZL171310xLM14	50	52.33	85	97.33	189.33	4.7	84.26	15.07	4.12	14.51	28.82	7502.96
29	V25xCML451	51	53	86	96.33	195.67	3.83	74.77	13.83	4.09	14.36	29.41	5942.08
30	V25xCAL1415	53	55.67	88	96.67	190	2.6	78.13	12.67	4.18	11.87	20.71	4290.99
31	V25xLM13	48.67	51.67	83.67	95	195.67	2.6	79.45	11.97	4.48	12.39	20.26	4312.08
32	V25xLM14	51.67	53.33	86.67	108.33	216.33	4.63	81.05	16.27	3.84	15.97	27.19	7897.67
33	Umerkote-4-1xCML451	48.33	50.67	83.33	90.67	181	3.47	83.58	11.83	4.6	15.25	19.77	6050.54
34	Umerkote-4-1xCAL1415	52.33	55.33	87.33	99.67	208	3.13	82.59	12.93	4.25	14.28	19.99	5471.28
35	Umerkote-4-1xLM13	50.67	53.33	85.67	101.67	209.67	3.53	80.68	13.17	4.39	14	24.18	6043.19
36	Umerkote-4-1xLM14	51.33	54	86.33	97.33	198.67	3.9	77.68	13.73	4.52	13.73	21.81	6354.29
37	VL20146xCML451	52.33	54.67	87.33	87.67	195.67	3.93	77.82	14.67	4.64	13.24	22.68	6439.38
38	VL20146xCAL1415	49.67	51.67	84.67	107.33	210.67	3.37	79	12.83	4.21	13.84	19.57	5585.18
39	VL20146xLM13	51.33	53.67	86.33	96	204.33	3.3	83.64	12.37	4.34	13.74	23.77	5822.25
40	VL20146xLM14	53	55.67	88	109	215.67	4.07	79.57	15.9	4.3	14.09	29.04	6849.63
41	VL70040xCML451	42	44.33	88.67	83.33	179	4.23	79.19	13.17	4.34	14.85	24.01	7050.63
42	VL70040xCAL1415	55.33	57.67	86.33	93.67	190	3.9	83.49	13.03	3.92	12.09	20.89	6846.92
43	VL70040xLM13	48.67	51.67	83.67	100.67	213.67	4.43	81.79	13.6	4.1	13.93	25.96	7547.54
44	VL70040xLM14	49.33	51.67	84.33	101	208.67	4.97	83.52	15	4.28	15.21	28.79	8547.81
45	VL18989xCML451	48.67	51	83.67	89.67	182.67	3.2	82.84	13.83	4.22	13.9	21.99	5230.63
46	VL18989xCAL1415	51.67	54.67	86.67	91	192.33	4.27	81.23	15	4.13	12.98	23.23	7166.96
47	VL18989xLM13	54.33	57	86.67	97.33	189.67	4.37	79.89	14.43	4.32	13.79	22.72	7245.96
48	VL18989xLM14	54.33	56	86.67	103.33	208.67	3.57	81.15	13.43	4.22	13.75	27.9	6160.38

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49	CML425-4xCML451	50.67	53	85.67	88.33	191.67	2.83	79.42	14.8	4.61	12.77	21.38	4783.03
50	CML425-4xCAL1415	51.33	54	86.33	102	195	2.83	85.06	14.7	4.2	13.12	24.65	5050.11
51	CML425-4xLM13	51	53.67	86	96.67	189.67	3.17	82.63	13.83	4.06	13.16	28.03	5528.79
52	CML425-4xLM14	50.33	53.33	85.33	114	216.33	5.8	82.89	17.4	4.03	15.22	31.74	10098.6
53	VL20160xCML451	50.67	53	85.67	93	193.33	3.87	84.61	15.3	4.59	14.19	24.23	6925.01
54	VL20160xCAL1415	50.67	52.67	85.67	104	209.67	4.27	85.3	16.17	4.61	14.81	27.38	7686
55	VL20160xLM13	50.67	53.33	85.67	102	152.33	4.57	83.12	15.67	4.4	13.46	26.29	8006.86
56	VL20160xLM14	50.33	53.33	85.33	97.33	190	5.37	80.88	17.2	4.18	15.23	27.98	8927.22
57	VL143906xCML451	49.67	52	84.67	100	201	3.87	81.21	14.93	4.16	13.24	27.69	6602.07
58	VL143906xCAL1415	48.33	50.67	83.33	83.67	160	2.9	82.51	18	4.44	13.53	24.22	5026.01
59	VL143906xLM13	48.33	50.67	83.33	116	229.67	5.53	80.17	17.13	4.08	15.09	24.89	9376.07
60	VL143906xLM14	51.67	54.33	86.67	100.67	213	2.8	83.27	15.9	3.87	16.07	22.28	4984.14
61	CML470-1xCML451	50.33	52.33	85.33	104.67	234.67	3.47	82.79	16.07	4.21	12.94	30.91	6022.27
62	CML470-1xCAL1415	50.67	53	85.67	90	179.67	3.67	85.37	14.67	4.28	13.8	25.78	6662.66
63	CML470-1xLM13	51.67	53.67	86.67	100.33	195	4.6	80.99	16.17	4.13	14.52	24.9	7836.34
64	CML470-1xLM14	52.33	54.67	87.33	104.67	213.67	3.43	78.13	16	4.26	13.93	26.03	5524.35
65	VL71915xCML451	49.33	51.67	84.33	101	211.67	3.13	76.84	14.83	4.33	11.84	25.35	4954.8
66	VL71915xCAL1415	50.33	52.33	85.33	101	234.67	3.23	80.03	15.57	3.98	13.28	27.71	5503.19
67	VL71915xLM13	50.33	52.67	85.33	97.33	218.33	4.1	79.62	16.33	4.12	13	27.44	6941.36
68	VL71915xLM14	51.33	53.33	86.33	101	216.67	5.37	79.16	16	3.99	14.63	28.25	8971.76
69	VL18938xCML451	49.33	51	84.33	118	237	3.87	80.2	16.5	3.99	14.61	25.06	6514.79
70	VL18938xCAL1415	48.67	50.67	83.67	116.67	237.33	3.67	78.01	10	4.44	12.72	20.06	6047.47
71	VL18938xLM13	49.67	52	84.67	102	193.67	2.8	83.44	11.33	4.21	12.64	19.84	4958.89
72	VL18938xLM14	55	57	66.67	93.67	188.33	3.37	83.52	16.1	4.08	15.71	27.05	5891.02
73	VL175899xCML451	51.33	54	86.33	112.67	238.67	5.27	82.24	18.4	3.95	14.33	33.43	9117.79
74	VL175899xCAL1415	50.67	53	85.67	104	206	4.57	82.66	15.83	4.17	15.08	24.5	7925.28
75	VL175899xLM13	53.33	56	88.33	112.67	220.67	2.8	85.47	13.5	4.1	13.14	21.02	4940.7
76	VL175899xLM14	49.33	51.33	84.33	100.33	203.33	5.53	83.42	17.33	4.5	14.42	28.09	9633.74
77	VL18201xCML451	50.33	52.67	85.33	112	215.33	3.67	79.96	13.83	4.09	11.96	22.29	6159.67
78	VL18201xCAL1415	48.67	51	83.67	99	198	2.47	78.73	12.77	3.86	13.8	22.67	4096.97
79	VL18201xLM13	53.33	56	88.33	110	205	2.8	80.46	14.67	4.34	11.77	26.1	4778.96
80	VL18201xLM14	51.33	54	86.33	106.33	203.67	4.97	81.84	15.9	4.06	13.89	32.17	8620.02
81	VL18941xCML451	50.33	53	85.33	97.67	201.33	4.27	83.43	12.6	4.21	12.44	20.06	7433.99
82	VL18941xCAL1415	49	51.67	84	86.67	160.33	4.47	81.46	14.33	4.46	13.97	23.73	7693.97
83	VL18941xLM13	51	52.67	86	91	181.67	4.2	83.02	14.93	3.92	13.55	21.52	7370.98
84	VL18941xLM14	51.67	54.33	86.67	94	185.33	3.2	77.34	16.37	4.09	14.47	28.44	5144.82
	Grand Mean	50.89	53.28	85.46	100.98	202.27	3.79	81.3	14.95	4.23	13.93	25.21	6408.21
	Min	42	44.33	66.67	83.33	152.33	2.47	74.77	10	3.84	11.77	18.86	4096.97
	Max	55.33	57.67	89	120.67	238.67	5.8	87.81	18.63	4.64	16.23	33.43	10098.6
	CV(%)	4.32	4.13	3.82	7.66	3.64	10.06	6.17	9.96	7.79	7.75	14.9	7.22
	SE(m)	1.27	1.27	1.88	4.46	4.25	0.22	2.89	0.85	0.19	0.62	2.16	267.37
DA: Days To 50% Anthesis; DS: Days To 50% Silking; DDH: Days To 75% Dry Husk; EH: Ear Height (cm); PH: Plant Height (cm); CY: Cob Yield (kg/ plot); SP: Shelling percentage (%); CL: Cob Length (cm); CD: Cob Diameter (cm); NKC: No Of Kernel Rows/ Cob; NKR: No Of Kernels/ Row; GY: Grain Yield (kg/ ha)													

among parents and their corresponding hybrids for all the characters studied (Mekasha *et al.*, 2021 and Arsode *et al.*, 2017).

Days to 50% anthesis

The number of days to reach 50% anthesis among parents ranged from 51.67 days in VL 71370 and CAL 1415 to 61.33 days in VL 20112 & LM 14, with a mean value of 55.92 days. Among the hybrids, this trait varied

from 42.00 days in VL 70040 × CML 451 to 55.33 days in VL 70040 × CAL 1415, with an overall mean of 50.89 days. The standard checks exhibited values ranging from 47.33 days in DKC 9126 to 51.33 days in HISHELL, similar result reported by (Arsode *et al.*, 2017).

Daysto 50% silking

For days to 50% silking, parents (Table 2), showed a

Table 4: Mean performance of checks for 12 characters in line x tester cross of maize.

Sr.	Characters	DA	DS	DDH	EH	PH	CY	SP	CL	CD	NKC	NKR	GY
1	NK 6240	49.33	51.67	81.33	105.35	196.37	4.26	84.55	15.83	4.37	15.33	24.33	7154.79
2	BIO 9682	50.67	52.67	82.67	106.17	192.76	4.71	83.23	17.77	4.22	17	30.33	8253.89
3	DKC 9126	47.33	51.33	83.33	93.49	188.24	4.2	85.87	17.82	4.38	14.33	32.67	7283.77
4	HISHELL	51.33	53.67	83.67	93.15	188.22	4.65	86.01	13.65	3.85	14.67	28.33	8146.96
	Grand Mean	49.67	52.34	82.75	99.54	191.4	4.46	84.92	16.27	4.21	15.33	28.92	7709.85
	Min	47.33	51.33	81.33	93.15	188.22	4.2	83.23	13.65	3.85	14.33	24.33	7154.79
	Max	51.33	53.67	83.67	106.17	196.37	4.71	86.01	17.82	4.38	17	32.67	8253.89

DA: Days To 50% Anthesis; DS: Days To 50% Silking; DDH: Days To 75% Dry Husk; EH: Ear Height (cm); PH: Plant Height (cm); CY: Cob Yield (kg/ plot); SP: Shelling percentage (%); CL: Cob Length (cm); CD: Cob Diameter (cm); NK: No Of Kernel Rows/ Cob; NKR: No Of Kernels/ Row; GY: Grain Yield (kg/ha)

range from 52.67 days in CML 425-4 to 62.67 days in LM 14, with an average of 57.24 days. The hybrids flowered comparatively earlier, with values ranging from 44.33 days in VL 70040 × CML 451 to 57.56 days in VL 70040 × CAL 1415, and a mean of 53.28 days. The standard checks recorded values between 51.33 and 53.63 days, closed result reported as Abdulazeez *et al.*, 2021).

Days to 75% dry husk

The duration to 75% dry husk among parents, ranged from 82.33 days in ZL 114150-1 to 97.67 days in VL 713701, with an average of 87.84 days. In hybrids, this trait varied from 66.67 days in VL 18938 × LM 14 to 89.00 days in VL 171522 × LM 14, with a mean of 85.46 days. The standard checks exhibited relatively shorter maturity duration, ranging from 81.33 days in NK 6240 to 83.67 days in HISHELL (Abebe *et al.*, 2020 and Gami *et al.*, 2018).

Ear height (cm)

The ear height among parents ranged from 53.20 cm in VL 18941 to 86.70 cm in VL 171522, with a mean of 65.27 cm. Among hybrids, ear height varied widely from 83.33 cm in VL 70040 × CML 451 to 120.67 cm in VL 32389-3 × CAL-1415, with an average of 100.98 cm. The standard checks recorded ear heights ranging from 93.15 cm to 106.17 cm (Aminu *et al.*, 2014) presented in Table 4.

Plant height (cm)

Table 2 showed that significant variation was also observed for plant height, which ranged from 103.43 cm in VL 71915 to 182.53 cm in VL 171522 among parents. In hybrids, plant height varied from 152.33 cm in VL 20160 × LM13 to 238.67 cm in VL 175899 × CML 451, with mean values of 137.87 cm and 202.27 cm for parents and hybrids, respectively. The standard checks recorded plant heights between 188.22 cm and 196.37 cm (Barh *et al.*, 2015).

Cob yield per plot/Kg

The cob yield per plot among parents (Table 2),

ranged from 2.76 kg in LM 14 to 3.31 kg in CML 451, with an average of 3.00 kg. In hybrids, cob yield varied from 2.47 kg in VL 18201 × CAL 1415 to 5.80 kg in CML 425-4 × LM 14, with a mean of 3.79 kg, indicating superior performance of hybrids over parents. The standard checks recorded cob yields ranging from 4.20 kg to 4.71 kg per plot (Bekele and Rao, 2013 and Gami *et al.*, 2018).

Shelling percentage (%)

The shelling percentage among parents ranged from 65.76% in LM 14 to 87.90% in VL 20112, with an average of 77.64%. Among hybrids, shelling percentage ranged from 74.77% in V 25 × CML 451 to 87.81% in ZL 114150-1 × CAL 1415, with a higher mean value of 81.30%. The standard checks exhibited shelling percentages between 83.23% and 86.01% (Chaudhary *et al.*, 2019 and Gurjar *et al.*, 2022) presented Table 2.

Cob length (cm)

For cob length, parents (Table 2) exhibited a range from 8.73 cm in VL 71915 to 15.43 cm in VL 71493, with a mean of 11.76 cm, whereas hybrids showed a wider range from 10.00 cm in VL 18938 × CAL 1415 to 18.63 cm in ZL 171310 × CAL 1415, with an average of 14.95 cm. The standard checks recorded cob lengths between 13.65 cm and 17.82 cm similar as Chaurasia, *et al.*, 2021, Panda *et al.*, 2017 and Kumar *et al.*, 2015.

Cob diameter (cm)

The cob diameter (Table 2) among parents ranged from 2.82 cm in Umerkote-4-1 to 4.27 cm in CML 425-4, with a mean of 3.62 cm. In hybrids, cob diameter varied from 3.84 cm in V 25 × LM 14 to 4.64 cm in VL 18941 × CAL 1, with an overall mean of 4.23 cm. The standard checks recorded cob diameters ranging from 3.85 cm to 4.38 cm (Darshan, and Marker, 2019 and Panwar *et al.*, 2013).

Number of kernel rows per cob

The number of kernel rows per cob varied from 9.74 in Umerkote-4-1 to 13.98 in LM 14 among parents, with

an average of 12.21, while hybrids showed values ranging from 11.77 in VL 18201×LM 13 to 16.23 in VL 32389-3 × CML 451, with a higher mean of 13.93. The standard checks recorded values between 14.33 (for DKC 9126) to 17 (for BIO 9682), similar as reported by Kumar *et al.*, 2019 and Sultan *et al.*, 2016.

Number of kernels per row

Table 2 show that, the number of kernels per row ranged from 16.65 in CAL 1415 to 24.78 in CML 425-4 among parents, with a mean of 19.40, whereas hybrids ranged from 18.86 in ZL 114150-1 × CAL 1415 to 33.43 in VL 175899 × CML 451, with a mean of 25.21. The standard checks exhibited mean values between 24.33 and 32.67, similar result reported Kumar *et al.*, 2019.

Grain Yield (kg/ha)

The grain yield among parents (Table-2) varied from 3821.84 kg ha⁻¹ in LM 14 to 5733.49 kg ha⁻¹ in VL 20160, with a mean of 4921.24 kg ha⁻¹. Among hybrids, grain yield ranged from 4096.97 kg ha⁻¹ in VL 18201 × CAL 1415 to 10098.60 kg ha⁻¹ in CML 425-4 × LM 14, with a significantly higher mean of 6408.21 kg ha⁻¹, demonstrating the superior performance of hybrids over parents. The standard checks recorded grain yields ranging from 7154.79 kg ha⁻¹ in NK 6240 to 8253.89 kg ha⁻¹ in BIO 9682, similar as reported by Mostafa, 2018 and Tabu *et al.*, 2023.

Conclusion

This study showed significant genetic variability among maize parents and their F₁ hybrids for all traits related to growth, flowering, and yield. The notable differences between genotypes, as well as between parents and hybrids, confirmed the presence of heterosis and highlighted the hybrids' advantages over parental lines for most traits. The earlier flowering in some hybrids suggests that it is possible to develop early-maturing maize hybrids suitable for various agro-climatic conditions.

Mean performance analysis indicated that hybrids generally outperformed parents in key yield-related traits such as cob length, cob diameter, number of kernel rows per cob, number of kernels per row, shelling percentage, and grain yield. The hybrid CML 425-4 × LM 14 stood out as the best, achieving the highest grain yield, while several other hybrids also performed similarly or better than standard commercial checks.

Overall, these findings highlight the importance of mean performance evaluation in identifying superior genotypes and promising hybrid combinations. The results provide useful information for maize breeding programs and suggest that the identified superior hybrids should be tested

across different locations and seasons for potential commercial use. This study contributes to ongoing efforts to improve maize productivity through systematic hybrid breeding strategies.

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