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RESEARCH

Agro-Morphological Evaluation of Hybrid Maize (*Zea mays*) in the Subtropical Region of Nepal

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Abstract

Agro-morphological characterization is crucial to evaluate the performance of maize hybrids on the basis of various traits and to identify superior hybrids with desirable features. The objective of this research was to identify the superior maize hybrid based on field performance. A total of thirteen maize hybrids were evaluated in a randomized complete block design with three replications at Sharanamati, Jhapa, Nepal during March-July, 2024. All the data except grain yield was recorded from five sample plants in each plot where grain yield was recorded from the whole plot and statistical analysis was done using R-studio. The results revealed that Superking-4455 is more appropriate for areas with shorter growing seasons since it generally flowers sooner in comparison to other genotypes such as INH-5619 and RH-6. Shorter plants like PAC-7202309 were found to be more resistant to lodging and are preferred in certain regions where wind or heavy rains are common over tall varieties like Star-56. The maximum grain yield was 10.09 t/ha which was achieved by Star-56, closely followed by Superking-4455 and RH-6 whose yield was 9.67 t/ha and 9.54 t/ha respectively. PAC-7202309 produced the lowest yield which was 4.49 t/ha, most likely as a result of its low TGW, NOP, and NOC. The results suggested that, while low-performing genotypes like PAC-7202309 need more research or breeding and agronomic methods to improve their performance, high-performing genotypes like RH-6, Star-56, and Superking-4455 are excellent possibilities for enhancing maize output in Saranamati, Jhapa.

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Statement of Sustainability: By finding high-yielding, climate-resilient maize hybrids that can improve food production in Nepal's rainfed systems, this research advances Sustainable Development Goal 2 (Zero Hunger) (United Nations, 2015). The study supports sustainable agricultural intensification without increasing the amount of land under cultivation by encouraging cultivars with improved performance and adaptability (Pretty et al., 2018), which is in line with SDG 12 (Responsible Consumption and Production) (United Nations, 2015). Additionally, data-driven policies for rural development and agricultural modernization that promote resilient livelihoods are informed by the work (FAO, 2019).

1. Introduction

Maize (*Zea mays*), one of the most important cereals after paddy in Nepal, is widely used for feed, food, and fodder (Wagle et al., 2020). It occupies 940256 ha of land with 2976490 t production and 3.16 t/ha productivity (FOASTAT, 2024). In the world scenario, maize productivity in Nepal is seen to be extremely low, due to which, despite maize contributing 25.4% of the total edible production of the country (MOALD, 2023), still 51.8% and 25.2% of households are food insecure and under the poverty line, respectively (Sharma and Pudasaini, 2020). Hence, for Nepal to be self-sufficient and obtain food security, there is an immense need to shift OPV selections into hybrid maize cultivation as there is a huge gap between the productivity of maize in Nepal with respect to its yielding potential (Joshi and Gautam, 2021; Kunwar and Shrestha, 2014). Especially in Jhapa, which is known for its significant agricultural output, with around 250,000 metric tons projected for the financial year 2079-80 from approximately 44,250 hectares of cultivated land (Gairhe et al., 2021). For three years in a row, from 2016–17 to 2018–19, the area was the focus of coordinated varietal trials with the goal of finding durable and high-yielding hybrid genotypes that can flourish in existing rainfed cropping systems (Rawal et al., 2023). Although hybrid maize is widely used as commercial winter maize in Terai regions of Nepal, high price of hybrid seed, a wide gap in anthesis-silking interval, poor seed set, difficulties in early generation lines, untimely availability of inputs (irrigation, fertilizer, pesticides etc.), requirement for seed replacement in every season, and high irrigation are the major problems associated with hybrid maize cultivation which farmers face (Kulkarni et al., 2023; Kunwar and Shrestha, 2014). Hence, continued research and development in hybrid maize varieties are necessary to enhance productivity, grain yield, disease resistance, resilience, and adaptability to the local environment in the face of environmental challenges and factors such as climate change and pest infestations that significantly impact maize production in Jhapa. Evaluating hybrid maize genotypes is crucial to finding improved cultivars that can flourish in particular climates, such as the inner terai (Tripathi et al., 2022). Several hybrid strains are put through a rigorous testing process in order to assess their performance in terms of yield and adaptability. These evaluations are a component of larger agricultural programs in Nepal that encourage modernizing farming methods through the provision of resources and incentives for farmers through initiatives such as the Prime Minister Agriculture Modernization Project and increase the potential for farmer adoption and commercial cultivation (Adhikari et al., 2024). Jhapa district was purposely selected for the study as it is a primary center for maize cultivation. The government initiative of declaring Jhapa as a maize zone, implemented as part of the Prime Minister Agriculture Modernization Project (PMAMP) has played a great role in emphasizing maize cultivation in Jhapa district. Despite hybrid maize becoming more widely available in Nepal, few localized evaluations have been carried out in the Eastern Terai region to ascertain genotype-specific performance in terms of yield and adaptation. There is a lack of region-specific recommendations for Jhapa, a designated maize production zone because the majority of studies have concentrated on hill regions or overall national averages. By assessing thirteen hybrid maize genotypes in Jhapa under rainfed circumstances, our study fills that study gap. Based on field performance and yield-contributing features, the main goal of this study was to identify high-performing hybrid maize genotypes and suggest the best varieties for Eastern Nepal's maize-growing regions.

2. Materials and Methods

2.1. Study Area and Climate

The experiment was carried out in the PMAMP command area at a farmer's field from the 2nd of March 2024 to the 7th of July 2024. The research site is situated at 26° 53′ 36″ N latitude and 87° 88′ 44″ E longitude at an altitude of 113 meters above sea level. Table 1 is the list of genotypes used in this research. The research site is found to have a humid subtropical climate with the average temperature ranging from about 22.18°C -31°C during March, with April being the hottest and most humid and March being the coolest. The experimental site experiences about 2500 mm of rainfall annually with July recording the highest monthly precipitation (~552mm).

Table 1. List of 13 hybrid maize genotypes used for the experiment.

S.N	Genotypes	Source
1	10V10	Muktinath Krishi Company
2	Badshah-70	Karki Agrovet
3	INH-5619	Muktinath Krishi Company
4	NMH-589	Muktinath Krishi Company
5	PAC-7202304	Muktinath Krishi Company
6	PAC-72023097	Muktinath Krishi Company
7	STAR- 56	Karki Agrovet
8	Superking-4455	Karki Agrovet
9	TX-396	Muktinath Krishi Company
10	RH-6	NMRP
11	RH-12	NMRP
12	RH-16	NMRP
13	RH-10	NMRP

2.2. Experimental Design and Layout

A field experiment was conducted using thirteen multinational hybrid maize genotypes, arranged in a Randomized Complete Block Design (RCBD) with three replications. Each experimental plot measured 5 meters in length and 0.75 meters in width and consisted of four rows. The plant-to-plant spacing was maintained at 0.20 meters. A pre-emergence herbicide mixture, comprising atrazine at a concentration of 2.5 mL per liter, was applied 72 hours after sowing to control weed emergence. Irrigation was administered at critical growth stages, namely knee-high, tasseling, and milking, to ensure optimal plant development. The fertilizer application followed the recommended dose of NPK at 120:60:40 kg/ha. Nitrogen was supplied in three splits: 50% as a basal dose and the remaining 50% was side-dressed at the six-leaf and knee-high stages using urea (46% N). Both phosphorus, in the form of diammonium phosphate (DAP), and potassium, as muriate of potash (MOP), were applied entirely as a basal dose at the time of sowing. Sowing was carried out in March, and all standard agronomic practices were followed uniformly throughout the crop-growing season.

2.3. Data Recorded

Data were collected by randomly selecting five representative plants from each block to record phenological and growth parameters. The recorded traits included plant height (cm), ear height (cm), cob length (cm), cob diameter (cm), moisture content (%), number of kernels per row, number of rows per cob, and thousand kernel weight (g). Grain yield data were obtained from the entire plot area to ensure a comprehensive assessment. Phenological observations, such as days to 50% tasseling and days to 50% silking, were recorded on a plot basis, and the silking-tasseling interval was subsequently calculated. The thousand kernel weight was measured after adjusting the grain moisture content to 12.5% to standardize comparisons. Grain yield (kg ha^{-1}) was calculated using the formula proposed by Kafle et al. (2020).

$$\text{Grain yield (kg ha}^{-1}) = [\text{E.W (kg plot}^{-1}) \times (100 - \text{GMH}) \times \text{C.S} \times 10000] / [(100 - \text{GMD}) \times \text{PHA}]$$

Where, E.W = Ear fresh mass in Kilograms per plot at the point of harvest; GMH = Grain moisture level (%) at the time of harvest; GMD = Preferred grain moisture level, i.e. 12.5%; PHA = Effective harvested plot area (m^2); C.S = Cob-shelling ratio, set to 0.8.

2.4. Statistical Analysis

All data were analyzed using RStudio. Analysis of variance(ANOVA) was performed to assess genotype effects. The least significant difference (LSD) test at $p<0.05$ was used to compare the mean. Relationships between yield and other characteristics were examined by determining Pearson's correlation coefficients among traits.

3. Results and Discussion

3.1. Phenological Traits and Flowering Synchrony

The wide range of phenological responses from maize hybrids demonstrated how adaptable they were to the Jhapa climate. Significant variations were observed in traits like days to anthesis, silking, and plant height as shown in Table 2. RH-16 and Superking-4455, two earlier flowering hybrids, were more suited for regions with shorter growing seasons since they reached the tasseling and silking stages earlier than others. The synchronization of pollen shedding and silk emerging was better in genotypes with shorter anthesis-silking intervals (ASI), such as RH-16 and RH-12. This is important for the best kernel development and final grain output under rainfed stress circumstances (Santos et al., 2020; Ayesiga et al., 2023). Even while late-maturing hybrids like INH-5619 have longer vegetative stages, they run the danger of having fewer successful pollination attempts if blooming occurs during stressful times. According to numerous reports, short ASI improves reproductive resistance in the face of abiotic stress (Hudson et al., 2022). The importance of early and synchronized blooming features for genotype selection under Eastern Terai environments is highlighted by these findings.

3.2. Growth and Morphological Attributes

The genotypes differed greatly in morphological characteristics including plant and ear height, which affected yield potential and lodging susceptibility. Strong growth was shown by taller genotypes like RH-6 and Star-56, which may help increase biomass output and light interception. Excessive height, however, may make lodging more likely in the area's frequent high winds or heavy rains (Laserna et al., 2012). Although shorter hybrids, like PAC-7202309, were less likely to lodge, they also showed poorer biomass accumulation and ear positioning, which may help to explain their poor yield performance. These findings highlight how crucial it is for hybrid breeding efforts to strike a balance between height and structural stability. Ear height was significantly higher in INH-5619 and PAC-7202304, which can be advantageous if supported by sturdy stalks.

3.3. Yield and Yield-Contributing Traits

With notable variations in cob and kernel characteristics, the hybrids' grain production varied from moderate to high among genotypes (Table 3). In line with results from previous regional examinations, top-performing hybrids such as Star-56, Superking-4455, and RH-6 continuously produced more than the check variety RH-10 (Rawal et al., 2023). Favorable combinations of cob length, diameter, kernel number, and thousand-grain weight (TGW) were present in these hybrids; these factors are known to have a significant impact on grain output (Kafle et al., 2020; Badu-Apraku et al., 2003). However, PAC-7202309 produced the lowest yield, primarily because of its poor cob development and lower kernel weight. According to these results, strong reproductive performance is important to ensure productivity.

Table 2. Descriptive statistics and testing of hypothesis for the flowering and height traits hybrid maize genotypes at Saranamati, Jhapa.

Treatment	AD	SD	ASI	PH	EH
10V10	66.67^{b}	70.33^{b}	3.67^{ab}	204.8^{ab}	87.1^{f}
BADSHAH-70	67.33^{b}	70.67^{ab}	3.33^{bc}	196.93^{bcd}	103^{cde}
INH-5619	68.67^{a}	71.67^{a}	3^{c}	203.63^{abc}	117.37^{a}
NMH-589	64.67^{c}	67.67^{de}	3^{c}	183.93^{de}	105.93^{bcde}
PAC-7202304	67^{b}	71^{ab}	4^{a}	206.47^{ab}	120.77^{a}
PAC-7202309	67.33^{b}	70.33^{b}	3^{c}	138.67^{f}	75.39
RH-12	66.67^{b}	70.67^{ab}	4^{a}	181.83^{e}	99.87^{de}
RH-16	64.67^{c}	66.67^{e}	2^{d}	190.77^{cde}	101.73^{de}
RH-6	67.67^{ab}	71.33^{ab}	3.67^{ab}	211.8^{a}	116.83^{a}
STAR-56	65.33^{c}	68.33^{cd}	3^{c}	216.8^{a}	113.8^{abc}
SUPERKING4455	64.33^{c}	67.33^{de}	3^{c}	186.4^{de}	115.8^{ab}
TX-369	67^{b}	70.33^{b}	3.33^{bc}	182^{e}	109.9^{abcd}
RH-10	67^{b}	69^{c}	2^{d}	182.93^{de}	95.1^{ef}
F value	***	***	***	***	***
CV	1.05	1.03	10.15	4.36	6.19
LSD	1.17	1.2	0.54	14.01	10.88
GM	66.49	69.64	3.15	191.3	104.81

Note: (*: significant at 5% level of significance, **: significant at 1% level of significance, and ns: non-significant), (AD: Days to 50% anthesis, SD: Days to 50% silking, ASI: Anthesis-Silking Interval, PH: Plant Height, EH: Ear Height).

Table 3. Descriptive statistics and testing of hypothesis for the yield attributing traits of hybrid maize genotypes at Saranamati, Jhapa.

Treatments	CL	CD	RPC	KPR	NOP	NOC	TGW	GY
10V10	18.4^{abcdef}	4.77^{bc}	14^{bc}	35.33^{bc}	25290.22^{cd}	24046.43^{bc}	0.31^{de}	5.29^{bc}
BADSHAH-70	18.91^{abcde}	5.01^{b}	14.67^{bc}	34.33^{bcd}	37313.43^{bc}	35240.46^{ab}	0.38^{abc}	8.1^{ab}
INH-5619	17.87^{cdef}	5.36^{a}	13.67^{bc}	32.33^{bcd}	42288.56^{ab}	36898.84^{a}	0.39^{ab}	7.46^{ab}
NMH-589	18.31^{bcdef}	4.93^{bc}	14.33^{bc}	33^{bcd}	42703.15^{ab}	42703.15^{a}	0.34^{cde}	8.85^{a}
PAC-7202304	20.05^{a}	4.83^{bc}	13.33^{c}	31.33^{cd}	39386.4^{b}	38142.62^{a}	0.3^{e}	9.51^{a}
PAC-7202309	17.33^{ef}	4.98^{bc}	14b^{c}	30.33^{d}	22388.06^{d}	20315.^{c}	0.37^{abc}	4.49^{c}
RH-12	19.72^{ab}	4.79^{bc}	14.6^{bc}	41^{a}	39801^{b}	39386.4^{a}	0.35^{abcde}	9.31^{a}
RH-16	17.04^{f}	4.69^{c}	15.33^{b}	33.33^{bcd}	41873.96^{ab}	36069.65^{a}	0.35^{abcde}	5.29^{bc}
RH-6	17.43^{def}	4.97^{bc}	14b^{c}	34.33^{bcd}	53067.99^{a}	43946.93^{a}	0.39^{ab}	9.54^{a}
STAR-56	19.63^{ab}	5.01^{b}	14b^{c}	35.33^{bc}	43532.34^{ab}	39801^{a}	0.34^{bcde}	10.09^{a}
SUPERKING-4455	19.36^{abc}	4.86^{bc}	13.67^{bc}	36.67^{ab}	41459.37^{ab}	36484.25^{a}	0.39^{a}	9.67^{a}
TX-369	17.15^{f}	4.82^{bc}	15^{bc}	33.67^{bcd}	45605.31^{ab}	38971.81^{a}	0.35^{abcd}	8.77^{a}
RH-10 (Check)	19.04^{abcd}	4.99^{bc}	18.33^{a}	34.33^{bcd}	46434.49^{ab}	44361.53^{a}	0.36^{abc}	9.22^{a}
F value	**	*.	**	*	**	**	*	**
CV	5.24	3.66	7.31	7.62	18.65	18.27	8.33	21.25
LSD	1.63	0.3	1.78	4.38	12547.15	11236.45	0.05	2.9
GM	18.49	4.92	14.54	34.26	40088.02	36643.7	0.36	8.12

Note: (* significant at 5% level of significance, **: significant at 1% level of significance, and ns: non-significant), (CL: Cob Length, CD: Cob Diameter, RPC: Number of Rows per Cob, KPR: Number of Kernels per row, NOP: Number of Plants per hectare, NOC: Number of Cobs per hectare, TGW: Thousand Grain Weight, GY: Grain Yield

3.4. Correlation and Trait Association Analysis

The variations in yield among hybrids were somewhat explained by strong positive correlations between yield and certain traits (Table 4). Correlation analysis revealed the positive and moderate significance of traits like number of cobs and number of plants per hectare, thousand grain weight, and cob length to the total grain yield indicating that yield will substantially increase with the increment in these parameters. Correlation analysis revealed the positive and moderate significance of traits like the number of cobs and number of plants per hectare, thousand-grain weight, and cob length to the total grain yield. This finding was slightly similar (Raut et al., 2017). Meanwhile, days to maturity or days to 50% anthesis and silking had a negative but non-significant correlation with total grain yield. This result was similar to the results of (Ghimire et al., 2015). Numerous researchers have reported variations in grain yield, which aligns with the current findings. Badu-Apraku et al. (2003) and Hussain et al. (2011) found that the various genotypes tested for high yield in maize can vary. The present finding is strongly supported by (Ayesiga et al., 2023; Hudson et al., 2022) which found that there were highly significant differences among genotypes for grain yield and yield contributing traits. Correlation analysis revealed that the number of cobs and number of plants per hectare, thousand-grain weight, and cob length were the most yield-determining traits. Thus, to sum it up, it is important to improve the selection for those specific traits in order to improve the total grain yield and improve the present condition for food security in Nepal. The country's maize production system faces several limitations, but targeted interventions can significantly improve outcomes (Gairhe et al., 2021).

Table 4. Pearson's correlation coefficient among mean values of the phenotypic and yield attributing traits.

	AD	SD	ASI	PH	EH	NOC	NOP	CL	CD	RPC	KPR	TGW	GY
AD	1												
SD	.925**	1											
ASI	0.252	0.601**	1										
PH	-0.278	-0.334*	-0.266	1									
EH	-0.560**	-0.653**	-0.485**	.684**	1								
NOC	-0.149	-0.172	-0.126	-0.133	0.193	1							
NOP	-0.106	-0.127	-0.099	-0.299	0.094	0.873**	1						
CL	-0.138	-0.019	0.242	0.238	0.246	0.043	-0.052	1					
CD	0.333*	0.261	-0.036	-0.105	-0.094	0.014	0.075	0.212	1				
RPC	0.414**	.360*	0.046	-0.128	-0.218	-0.019	0.009	-0.032	0.557**	1			
KPR	0.084	0.232	.414**	0.15	0.11	-0.142	-0.128	.646**	0.184	0.024	1		
TGW	-0.01	-0.071	-0.158	-0.108	0.158	.414**	0.306	.372*	0.378*	-0.083	-0.032	1	
GY	-0.144	-0.063	0.144	-0.182	0.122	0.796**	0.774**	0.397*	0.132	0.04	0.144	0.499**	1

*: Correlation significant at 0.05 level and **: Correlation significant at 0.01 level., AD: Days to 50% anthesis, SD: Days to 50% silking, ASI: Anthesis-Silking Interval, PH: Plant Height, EH: Ear Height, CLEN: Cob Length, CD: Cob Diameter, RPC: Number of Rows per Cob, KPR: Number of Kernels per Row, NOP: Number of Plants per hectare, NOC: Number of Cobs per hectare, TGW: Thousand Grain Weight, GY: Grain Yield.

4. Conclusion

The study showed significant variations in all the qualitative and quantitative traits. Correlation analysis revealed that the number of cobs and number of plants per hectare, thousand-grain weight, and cob length were the most yield-determining traits as they showed positive and very strong significant correlation in comparison to total yield which means that as each of these parameters increases, the total yield also increases. The research findings lead to the conclusion that Star-56, Superking-4455, and RH-6, were the top-performing varieties which combined high cob and kernel counts with good plant stature and early tasseling. Shorter varieties like PAC-7202309, despite lodging resistance, could not compensate with yield. These results suggest that Star-56, Superking-4455, and RH-6 are excellent candidates for Jhapa's maize zone, while low-yielding genotypes may require further breeding or improved management to realize their potential.

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References

Adhikari, B. N., Ghimire, S. K., Pandey, M. P., & Dhakal, K. H. (2024). Performance of single cross maize hybrids for summer planting in western Nepal. *Agronomy Journal of Nepal,* 8(1), 70–80. https://doi.org/10.3126/ajn.v8i1.70775

Ayesiga, S. B., Rubaihayo, P., Oloka, B. M., Dramadri, I. O., Edema, R., & Sserumaga, J. P. (2023). Genetic variation among tropical maize inbred lines from NARS and CGIAR breeding programs. *Plant Molecular Biology Reporter,* 41(2), 209–217.

Badu-Apraku, B., Abamu, F. J., Menkir, A., Fakorede, M. A. B., & Obeng-Antwi, K. C. (2003). Genotype by environment interactions in the regional early variety trials in West and Central Africa. *Maydica,* 48(2), 93–104.

FAO. (2019). The state of food and agriculture 2019: Moving forward on food loss and waste reduction. Food and Agriculture Organization of the United Nations.

FAO. (2023). *Data release*. Food and Agriculture Organization of the United Nations.

Gairhe, S., Timsina, K. P., Ghimire, Y. N., Lamichhane, J., Subedi, S., & Shrestha, J. (2021). Production and distribution system of maize seed in Nepal. *Heliyon, 7*(4), e06775. https://doi.org/10.1016/j.heliyon.2021.e06775

Ghimire, B., & Timsina, D. (2015). Analysis of yield and yield attributing traits of maize genotypes in Chitwan, Nepal. *World Journal of Agricultural Research,* 3(5), 153–162. https://doi.org/10.12691/wjar-3-5-2

Hudson, A. I., Odell, S. G., Dubreuil, P., Tixier, M. H., Praud, S., Runcie, D. E., & Ross-Ibarra, J. (2022). Analysis of genotype-by-environment interactions in a maize mapping population. *G3: Genes, Genomes, Genetics,* 12(3), jkac013.

Hussain, N., Khan, M. Y., & Baloch, M. S. (2011). Screening of maize varieties for grain yield at Dera Ismail Khan. *Journal of Animal and Plant Sciences,* 21(3), 626–628.

Joshi, P., & Gautam, D. (2021). Genetic insights on single cross maize hybrid and its importance on maize self-sufficiency in Nepal. *Archives of Agriculture and Environmental Science,* 6(2), 218–226. https://doi.org/10.26832/24566632.2021.0602014

Kafle, S., Adhikari, N. R., Sharma, S., & Shrestha, J. (2020). Performance evaluation of single-cross maize hybrids for flowering and yield traits. *Fundamental and Applied Agriculture,* 5(4), 590–597.

Kulkarni, A. P., Tripathi, M. P., Gautam, D., Koirala, K. B., Kandel, M., Regmi, D., & Zaidi, P. H. (2023). Impact of adoption of heat-stress tolerant maize hybrid on yield and profitability: Evidence from Terai region of Nepal. *Frontiers in Sustainable Food Systems,* 7, 1101717. https://doi.org/10.3389/fsufs.2023.1101717

Kunwar, C. B., & Shrestha, J. (2014). Evaluating performance of maize hybrids in Terai region of Nepal. *World Journal of Agricultural Research,* 2(1), 22–25. https://doi.org/10.12691/wjar-2-1-4

Laserna, M. P., Maddonni, G. A., & López, C. G. (2012). Phenotypic variations between non-transgenic and transgenic maize hybrids. *Field Crops Research,* 134, 175–184. https://doi.org/10.1016/j.fcr.2012.06.006

Ministry of Agriculture and Livestock Development (MoALD). (2023). Statistical information on Nepalese agriculture: 2079–80 (2022–23). Available online: https://moald.gov.np (accessed on 10 March 2025).

Pretty, J., Benton, T. G., Bharucha, Z. P., Dicks, L. V., Flora, C. B., Godfray, H. C. J., & Wratten, S. (2018). Global assessment of agricultural system redesign for sustainable intensification. *Nature Sustainability,* 1(8), 441–446. https://doi.org/10.1038/s41893-018-0114-0

Raut, S. K., Ghimire, S. K., Kharel, R., Kuwar, C. B., Sapkota, M., & Kushwaha, U. K. S. (2017). Study of yield and yield attributing traits of maize. *American Journal of Food Science and Health,* 3(6), 123–129. https://doi.org/10.11648/j.ajfsh.20170306.13

Rawal, S., Thapa, S., Singh, R. B., Tripathi, M. P., & Xiao, X. (2023). Agro-morphological characterization of maize hybrids and estimation of genetic parameters in mid-hills of Far-West Nepal. *Advances in Agriculture,* 2023, 6138682.

Santos, Á. D. O., Pinho, R. G. V., Souza, V. F. D., Guimarães, L. J. M., Balestre, M., Pires, L. P. M., & Silva, C. P. D. (2020). Grain yield, anthesis-silking interval and drought tolerance indices of tropical maize hybrids. *Crop Breeding and Applied Biotechnology,* 20(1), e202010. https://doi.org/10.1590/1984-70332020v20n1a10

Sharma, M., & Pudasaini, A. (2020). Where is Nepal in the food system transition? *South Asian Journal of Social Studies and Economics,* 8(3), 16–36. https://doi.org/10.9734/sajsse/2020/v8i330220

Tripathi, M. P., Gautam, D., Koirala, K. B., Shrestha, H. K., & Besir, A. (2022). Evaluation of pro-vitamin A enriched maize hybrids for fighting hidden hunger in Nepal. *Journal of Agriculture and Applied Biology,* 3(1), 19–27. https://doi.org/10.11594/jaab.03.01.03

United Nations. (2015). *Transforming our world: The 2030 Agenda for Sustainable Development*. Available online: https://sdgs.un.org/2030agenda (accessed on 10 March 2025).

Wagle, P., Poudel, A., & Neupane, B. (2020). Varietal evaluation of promising maize genotypes in mid hills of Nepal. *Journal of Agriculture and Natural Resources,* 3(2), 127–139. https://doi.org/10.3126/janr.v3i2.32491