Journal of Biological and Agricultural Advancements (JBAA) (2025). 3(2), 7-13
https://journalbaa.com/ ISSN: 3007-2999 (Online)

Research Article Open Access

Optimizing Sowing Dates for Growth and Yield Performance of Thailand-Originated Maize (*Zea mays* L.) Hybrids in the Semi-Arid Conditions of Faisalabad

Muhammad Asif[1*], Muhammad Talha[2], Muhammad Shoaib Razzaq[3], Waleed Abdullah[2], Shaheryar[1], Abdul Malik[4], Muhammad Osama bin Abid[2]

[1]Department of Agronomy, University of Agriculture, Faisalabad, Pakistan
[2]Institute of Biochemistry and Biotechnology, PMAS Arid Agriculture University, Rawalpindi, Pakistan
[3]Alma Mater Studiourm-Universita Di Bologna, Dipartimento di Scienze e Tecnologie Agro-Alimentari - DISTAL, Italy
[4]Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad, Pakistan
***Corresponding author e-mail**: m.asifuaf8322@gmail.com

ABSTRACT Crop production faces challenges due to increasing food demands of a growing population, exhausted natural resources, and climate variability. Climate change is a major factor affecting maize production. A field trial was conducted at the Agronomic Research Area, University of Agriculture, Faisalabad. The study employed a randomized complete block design with split plots, involving three replications and four maize hybrids: Pioneer 4040, Charoen Pokphand-1, Charoen Pokphand-2, and Charoen Pokphand-3. In 2021, three sowing dates—July 15, July 30, and August 15—were tested. Data were analyzed statistically using Fisher's Analysis of Variance and LSD test at a 5% significance level to identify differences among treatments. Standard procedures recorded yield parameters. Early sowing (July 15) resulted in maximum values for plant height (243.33 cm), cobs per plant (1.86), cob length (21.83 cm), cob diameter (4.40 cm), grains per row (41.23), 100-grain weight (33.30 g), biological yield (32.80 t/ha), grain yield (10.10 t/ha), and harvest index (41.35%). Conversely, late sowing (August 15) yielded minimum values for plant height (220 cm), cobs per plant (1.10), cob length (18.66 cm), cob diameter (3.40 cm), grains per row (29), 100-grain weight (26.46 g), biological yield (26.48 t/ha), grain yield (8.76 t/ha), and harvest index (34.39%). Hybrid P-4040 achieved maximum values for plant height, cobs per plant, cob length, cob diameter, grains per row, 100-grain weight, biological yield, grain yield, and harvest index with the first sowing date. Hybrid CP-1 showed peak performance for these parameters.

Keywords: *Maize; Sowing Date; Hybrids; Semi-arid Climate; Growth; Yield*

To cite this article: Asif, M., Talha, M., Razzaq, M.S., Abdullah, W., Shaheryar, Malik, A., Abid, M.O.B. (2025). Optimizing Sowing Dates for Growth and Yield Performance of Thailand-Originated Maize (*Zea mays* L.) Hybrids in the Semi-Arid Conditions of Faisalabad. *Journal of Biological and Agricultural Advancements*, 3(2), 7-13.

Article History: Received: 10 July 2025; **Accepted**: 09 August 2025; **Published Online**: 31 August 2025

INTRODUCTION Agriculture is a major part of the economy of Pakistan, and our population is directly supported by its output (Rehman et al., 2021). Pakistan is one of the world's agricultural emerging nations, and it depends on agriculture to generate foreign exchange, provide jobs, and foster the growth of other industrial businesses and sectors (Yogi et al., 2025). Maize has the flexibility to grow in a variety of environments, making it ideal for our cropping systems (An et al., 2024). Furthermore, maize is regarded as the most adaptable crop, with a wide range of capacities and adaptation to a variety of agro-climatic situations. Individual sowing is also attracted by its significant nutritional content, which includes 3% sugar, 10% protein, 1.7% ash, 8.5% fiber, 72% starch, and 4.8% oil. Maize is planted throughout Pakistan, having many growth stages as shown in Figure 1, with KPK and Punjab leading the way in terms of output. Maize is also grown in Gilgit and Azad Kashmir's steep terrain (Bezbaruah & Sarma Deka, 2021).

Maize is the 3rd most vital grain crop after wheat and rice in Pakistan, providing food, feed, and fodder for humans, poultry, and livestock, respectively (Saleem et al., 2009). Maize is a member of the Poaceae family and is a versatile crop that can be produced in a variety of agro-climatic zones across the world, including tropical, subtropical, and temperate regions. Maize accounts for 37% of global crop output of 1.1 billion tons for food for humans, feed for animals, and industrial purposes (FAO, 2024). Maize production in Pakistan has been annually increased due to increased area, improved seed variety accessibility, enhanced production of maize, and a boost in economic returns (Government of Pakistan, 2024). The forecast for global maize utilization is still pointing to a slight decline. World cereal stocks are forecasted to be 854 Mt in 2023, down 0.6% from 2021/22, because of lower production and higher feed use (FAO, 2022). Maize is currently the most widely grown and marketed crop in terms of production volume, and it is predicted to surpass it during the next decade. It is a versatile, multipurpose crop that is mostly used as feed worldwide (Erenstein et al., 2022).

One worldwide issue that seriously threatens the world's food supply is climate change. Weather patterns alter as temperatures rise, and crops may not be able to grow at all. There may be less food available globally as a result, which could raise the rate of starvation (Yuan et al., 2024). The biggest long-term danger to food security is climate change. For many nations, the impact of climate change on agriculture is a serious problem because growing numerous crops will become more challenging or impossible as temperatures rise. Higher temperatures can cause extreme weather conditions, such as droughts and floods, which could be the reason for a reduction in overall productivity and harm to crops (Habib-ur-Rahman et al., 2022). To overcome the climate change problem, there are several ways, like farmers choosing drought tolerant maize hybrids and adjusting the sowing dates. This activity would help them to grow and harvest more crops during low rainfall periods. Farmers can adapt improved irrigation systems or build new storage facilities to store excess water during the dry period (Youssef et al., 2023). It is need to look at techniques that could be the possible reason to reduce the carbon footprint to improve the climate on their farm (A. Rehman et al., 2021).

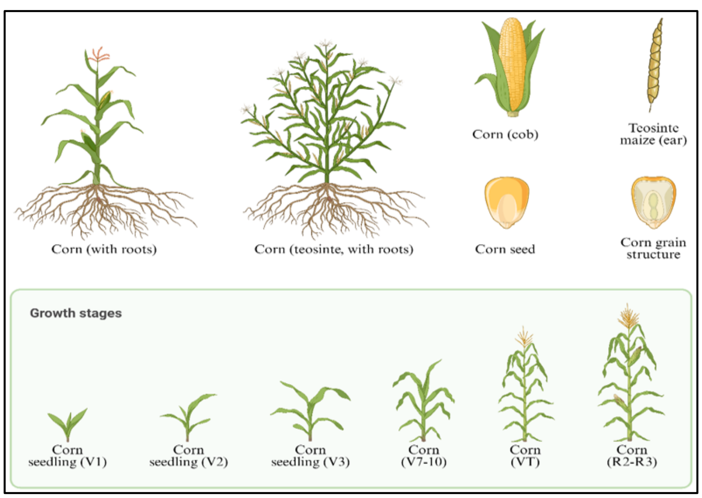

Figure 1: Phenological development pictorial view of maize. Figure created with BioRender.com (https://app.biorender.com/biorender templates)-accessed on 04 February 2025.

Future maize yields rely on farmers' production optimization strategies for the development of genetic potential, and plant breeders who create climatically adaptive genotypes (Butler et al., 2018). Over the past 40 years, breeding increased stress tolerance and the resulting ability to increase plant density has been associated with higher yields (He et al., 2022). Results present, yields have increased in all types of situations, including those with nitrogen and water deficiencies, and well water (Mueller et al., 2019). Due to favorable changes in the environment, the yield gained from these genetic and managerial innovations has increased by 5–10 % (Abendroth et al., 2021).

MATERIALS AND METHODS

A field experiment was conducted at the Agronomic Research Area, Department of Agronomy, University of Agriculture, Faisalabad in 2021. The layout of the research was RCBD, having 3 replications. Land preparation was done, followed by two ploughings. Seed rates were 20kg ha-1, Row spacing was 75cm, and Plant spacing was 20cm. Fertilizer application will be done at 225-140-90 kg NPK ha-1, respectively. Below are the details of treatments:

Treatments detail

Four maize hybrids were tested in the field with different seeding periods to see how well they performed. Factor A, Maize Hybrids, which included Charoen Pokphand 1 (CP1), Charoen Pokphand 2 (CP2), Charoen Pokphand 3 (CP3), and Pioneer 4040 (P4040), and Factor B, Sowing Time, which had three levels: July 15, July 30, and August 15, 2021, made up the experiment. The area was prepared using a tractor-driven disc harrow, cultivator, and plough to ensure consistent soil quality and fine tilth (Padjung et al., 2020). The seeds were manually sown on ridges at a rate of 8 kg per acre, with rows spaced 75 cm apart and plants spaced 20 cm apart. Beginning on July 15 and continuing for 15 days at a time, three sowings were conducted. To improve seed germination, each seeding was immediately followed by irrigation (Kovalenko et al., 2023).

While preparing beds, complete phosphorus (DAP) and potassium (K_2O) were applied, but nitrogen (urea) was divided into three equal parts. It was applied after 2nd irrigation of emergence and at the knee height stage, approximately 30 days after sowing, and at the tasseling stage (Sudding et al., 2021). A total of 10 irrigations were provided to complete the crucial growth stages (Sheldon et al., 2023). Atrazine and mesotrione (2 L ha^{-1}) were applied as a post-emergence weedicide to control weeds using a knapsack sprayer fitted with a flat fan nozzle (Mali et al., 2021). Three sprays (Emamectin, Lufenuron, and Carbosulfan) with intervals were applied to control stem borer and autumn armyworm infestations (Viteri & Linares-Ramírez, 2022).

Observations

A comprehensive set of observations was performed throughout the crop growth cycle to assess the performance of several maize hybrids under different sowing dates. By monitoring emergence daily until it was finished, the number of days to emergence was determined (Kimmelshue et al., 2022). For standardization, the number of plants per plot was counted and then converted to the number of plants per hectare (Bernhard & Below, 2020). A measuring tape was used to measure the height of ten randomly selected plants from each treatment plot in centimeters (Villaver, 2020). Ten representative cobs were measured for cob length using a measuring tape to assess yield-related characteristics (Putri et al., 2023). To determine how many cobs each plant produced, ten plants per plot were chosen at random (Das et al., 2020). A digital balance was used to weigh 100 grains that were randomly selected from each treatment's threshed produce to evaluate grain attributes (Babaji et al., 2014). Days to maturity were recorded as the number of days from sowing to when 50% of the plants exhibited physiological maturity, identified by black layer formation (Effendi et al., 2021). Grain yield per hectare was determined by harvesting and threshing the entire plot manually, then weighing the grains and converting the yield into tons per hectare.

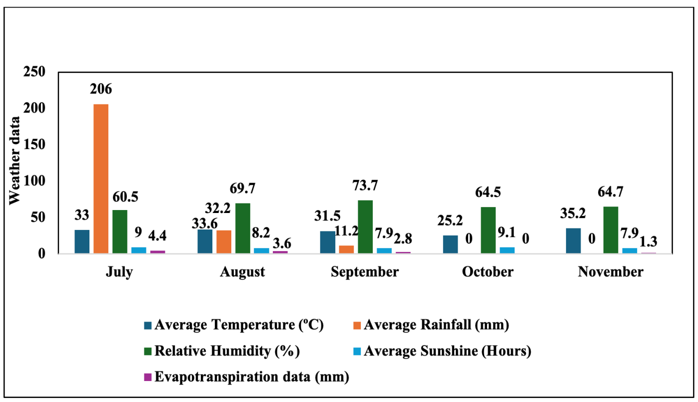

Figure 2: Weather data during the growing season

Similarly, the number of grains per cob was calculated by counting grains from ten randomly selected cobs per treatment (Iqbal et al., 2015). For biological yield, the total biomass from each plot was sun-dried for a week and weighed in kg per hectare. The harvest index was then calculated using the formula: Harvest Index (%) = (Grain Yield / Biological Yield) × 100 (Ion et al., 2015). Weather data was also recoded as shown in Figure 2.

Statistical analysis

The LSD test was performed to examine the variation between the means of several treatments at a 0.05 probability level after the research data were statistically evaluated using Fisher's analysis of variance technique (Steel et al., 1997).

RESULTS AND DISCUSSION

Using ANOVA-LSD, the effects of hybrid variety and sowing dates on the phenological and yield characteristics of maize hybrids of Thailand were evaluated. The information showed distinct patterns in response to hybrid adaptability and delayed sowing in the context of changing climate conditions. The ANOVA mean square (MS) values and treatment means for every characteristic under study are shown in Table 1.

Sowing dates had a highly significant ($p < 0.01$) impact on nearly all phenological, morphological, and yield-related parameters of maize hybrids, according to the results of the combined ANOVA (Table 1). However, hybrid differences were only significant for certain traits like silking, milking, cob length, 100-grain weight, grain yield, and harvest index. Except for characteristics like blister and milking stage, 100-grain weight, and harvest index, most hybrids responded consistently to the planting date, as indicated by the largely non-significant interaction between the two variables. With the sowing delay, the days to emerge increased steadily, rising from 4.74 days on July 15 to 6.77 days on August 15 (Figures 3, 4 & 5). The significant difference was confirmed by the related ANOVA mean square (MS = 12.32). Lower soil temperatures and decreased seed metabolic activity during the later sowing time are likely the reasons for the emergence delay. Recent research has documented similar patterns, emphasizing that temperature has a direct impact on early seedling emergence and seed germination rate, especially in tropical environments (Domokos et al., 2024). Early seeding greatly accelerated tasseling and silking in addition to accelerating emergence. Under 15 July seeding, tasseling might happen as early as 53.17 days, but under 15 August, it took 62.42 days. Likewise, at the same sowing dates, silking was seen at 60.41 and 72.75 days, which corresponded to highly significant MS values of 489.62 and 456.83. These results are consistent with field-based thermal time studies, which indicate that earlier sowing promotes better reproductive success by ensuring optimal vegetative growth and synchronization between pollen shed and silk emergence (Cao et al., 2024) This pattern was also observed at the blister and milking stages. Blisters appeared at 69.41 days and milking at 78.08 days in early planting. On the other hand, during late sowing, these stages were prolonged to 83.04 and 91.16 days, respectively, as shown in Figure 3. The ANOVA's associated MS values (556.92 and 514.22) verified significant statistical differences. Lower assimilate translocation, greater kernel abortion rates, and incomplete kernel development can result from longer grain filling times under colder nighttime temperatures. (Wu et al., 2024) claimed that lower temperatures during reproductive stages cause less starch to be synthesized and accumulated, which negatively impacts grain formation. This explains why later sowing dates result in a lower grain yield.

The impact of thermal units and radiation interception was demonstrated by the considerable decrease in plant height from 239.58 cm in early planting to 222.50 cm in late sowing (MS = 619.75). Pioneer 4040 continuously produced the tallest plants (231.89 cm) among the hybrids, indicating greater adaptability and robust development under ideal circumstances. Because gibberellin activity is decreased in cooler growth circumstances, reduced internodal elongation is frequently linked to reduced plant height with late sowing (An et al., 2024).

Cob-related characteristics were also impacted. The significant MS values (7.71 and 1.40) confirmed that the cob diameter declined from 4.20 cm to 3.52 cm, while the cob length decreased from 20.33 cm (15 July) to 18.79 cm (15 August). Both a decreased assimilate supply and a shorter cob development period are likely the reasons for this decline in sink size. Between sowing dates, grain yield dropped significantly from 9.68 t/ha to 8.57 t/ha (MS = 2.14). A reduction in grains per row (from 39.88

to 32.16) and a decrease in 100-grain weight (from 30.12 g to 27.42 g) are correlated with the significant yield decline associated with delayed sowing. Under ideal growth conditions, Pioneer 4040 recorded the maximum yield (9.63 t/ha) and 100-grain weight (30.14 g), confirming its exceptional physiological efficiency as shown in Figure 4. These findings have been confirmed by recent research, which shows that early sowing maximizes solar radiation utilization and prevents important growth phases from falling under terminal drought or cold temperatures (Sun et al., 2023).

Delays in planting also influenced biological yield, which decreased from 29.91 t/ha to 27.07 t/ha (MS = 22.09). A crucial indicator of dry matter partitioning, the harvest index, dropped sharply from 39.58% to 35.39% (MS = 65.29), indicating that grain yield efficiency was more negatively impacted than total biomass. Pioneer 4040 maintained the highest harvest index (38.05%) among hybrids, exhibiting superior translocation efficiency and source-sink connections. These harvest index decreases under stress or adverse conditions have been extensively documented and are usually linked to remobilization failure caused by stress or sink limitation (Akinnuoye-Adelabu & Modi, 2017).

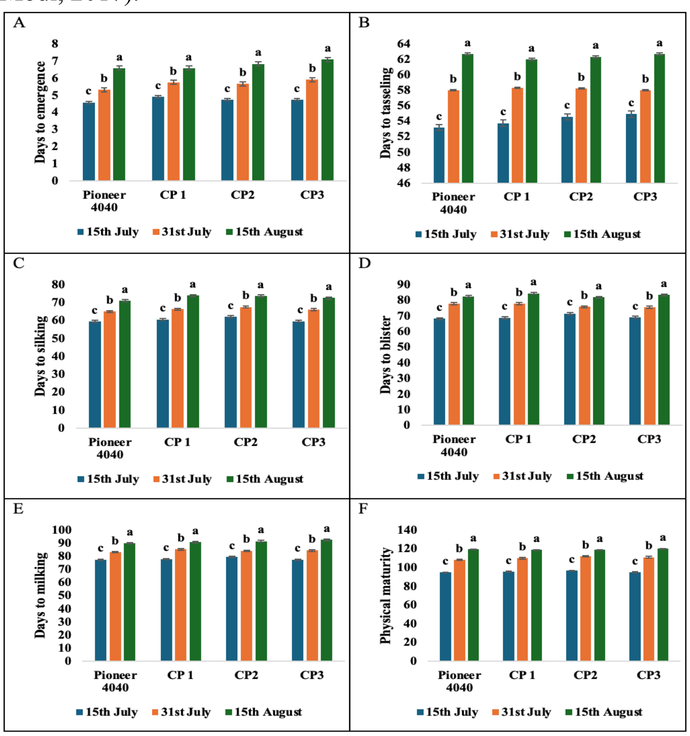

Figure 3: Effect of sowing time on phenology parameters of maize hybrids under semi-arid conditions of Punjab.

Only blister (MS = 4.74), milking (MS = 2.95), 100-grain weight (MS = 5.30), and harvest index (MS = 2.86) showed a statistically significant interaction between sowing date and hybrid, indicating that some hybrids reacted differently to different planting conditions. These features point to the existence of genotype × environment interaction, even though other traits showed similar trends across hybrids, as shown in Figure 5. For example, after late sowing, CP-2 and CP-3 fared poorly in yield and harvest index but displayed more stable cob characteristics. These findings provide evidence for the idea that environmental adaptability should be considered during hybrid selection, especially in the context of changing climatic conditions (Omar et al., 2022).

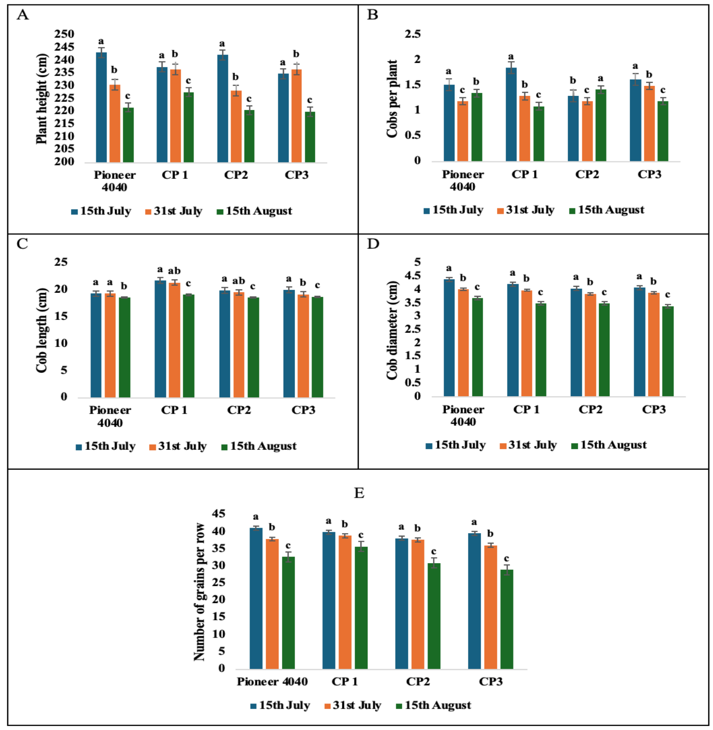

Figure 4: Effect of sowing time on growth parameters of maize hybrids under semi-arid conditions of Punjab.

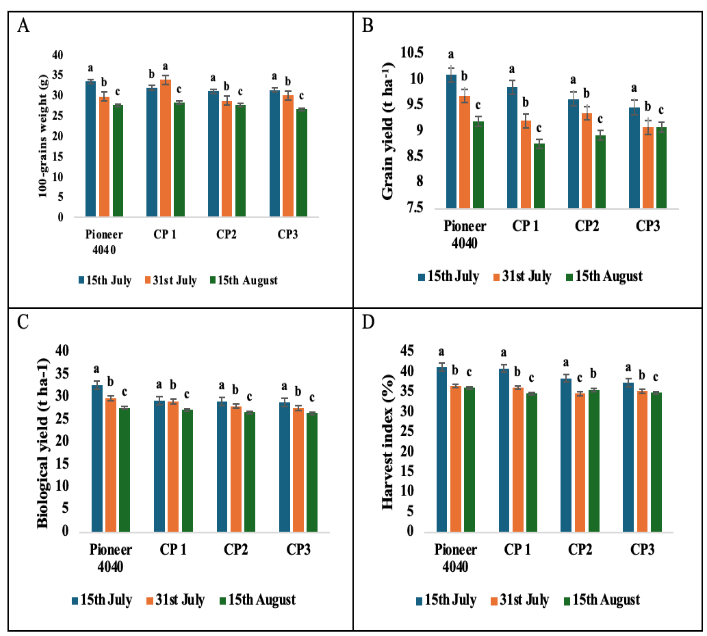

Figure 5: Effect of sowing time on yield parameters of maize hybrids under semi-arid conditions of Punjab

Table 1: Summary of Combined Mean Square (MS) from ANOVA

Source	**EM**	**TA**	**SK**	**BL**	**ML**	**MY**	**PH**	**C/P**	**CL**	**CD**	**G/R**	**100-GW**	**GY**	**BY**	**HI**
Replications (R)	0.48	68.76	0.085	1.84	1.42	5.30	6.75	0.088	3.18	0.016	5.23	1.03	0.078	4.28	0.87
Sowing Date (S)	12.32**	489.62**	456.83**	556.92**	514.22**	1748.13**	619.75**	0.352*	7.71*	1.40**	137.57**	61.08**	2.14**	22.09*	65.29**
Error 1 (R×S)	0.14	57.56	1.85	1.08	0.53	11.03	11.38	0.033	0.73	0.0008	9.53	3.03	0.034	2.13	1.60
Hybrids (H)	0.27ns	62.57ns	11.34**	3.60ns	3.08*	4.77ns	256.78ns	0.032ns	5.34*	0.116*	20.42*	8.89**	0.80**	10.58ns	8.54**
S×H Interaction	0.07ns	64.42ns	0.73ns	4.74*	2.95*	3.17ns	86.97ns	0.132ns	0.69ns	0.010	11.58ns	5.30**	0.044ns	3.61ns	2.86*
Error 2	0.10	72.76	0.78	1.19	0.62	2.31	99.35	0.163	1.62	0.011	4.49	1.22	0.056	4.10	1.06

**Significant at P<0.05, **Highly significant at P<0.01, ns = non-significant*
EM = Emergence, TA = Tasseling, SK = Silking, BL = Blister, ML = Milking, MY = Maturity, PH = Plant Height, C/P = Cobs/Plant, CL = Cob Length, CD = Cob Diameter, G/R = Grains/Row, 100-GW = 100-Grain Weight, GY = Grain Yield, BY = Biological Yield, HI = Harvest index

CONCLUSION

According to the study, the sowing date has a significant impact on the phenological development, yield components, and total productivity of maize hybrids that originated in Thailand. In order to achieve better cob development, higher grain weight, and better biomass partitioning, early seeding on July 15th greatly enhanced growth stages such as emergence, tasseling, silking, and maturity. Due to ideal weather at crucial growth times, early planted plots had significantly better grain yields and harvest indices. Across all sowing dates, Pioneer 4040 consistently outperformed the other genotypes under examination, demonstrating improved grain filling, increased flexibility, and higher yield performance. Although interaction effects were generally limited, some traits like milking, blister stage, and 100-grain weight showed significant genotype × environment responses. These results highlight the importance of matching sowing time with suitable hybrid choices to enhance resource use efficiency and yield stability. The findings are particularly relevant for climate-smart agricultural planning and sustainable maize production under tropical agro-ecological conditions.

REFERENCES

Abendroth, L. J., Miguez, F. E., Castellano, M. J., Carter, P. R., Messina, C. D., Dixon, P. M., & Hatfield, J. L. (2021). Lengthening of maize maturity time is not a widespread climate change adaptation strategy in the US Midwest. Global Change Biology, 27(11), 2426–2440.

Akinnuoye-Adelabu, D. B., & Modi, A. T. (2017). Planting Dates and Harvesting Stages Influence on Maize Yield under Rain-Fed Conditions. Journal of Agricultural Science, 9(9), 43.

An, L., Wei, H., Cheng, Y., Zou, J., Zuo, J., Liu, D., & Song, B. (2024). Adjusting the sowing date of fresh maize to promote grain filling, key starch synthesis enzymes, and yield. Plant, Soil and Environment, 70(7), 438–453.

Babaji, B. A., Yahaya, R. A., Mahadi, M. A., Jaliya, M. M., Ahmed, A., Sharifai, A. I., Kura, H. N., Arunah, U. L., Ibrahim, A., & Muhammad, A. A. (2014). Yield and yield attributes of extra-early maize (Zea mays l.) as affected by rates of NPK fertilizer succeeding chilli pepper (Capsicum frutescens) supplied with different rates sheep manure. Agrivita, 36(1), 1–8.

Bernhard, B. J., & Below, F. E. (2020). Plant population and row spacing effects on corn: Plant growth, phenology, and grain yield. Agronomy Journal, 112(4), 2456–2465.

Bezbaruah, R., & Sarma Deka, R. (2021). Enhancement of Productivity of Maize (Zea mays L.) by Adoption of Scientific Method of Cultivation. Journal of Community Mobilization and Sustainable Development, 16(3), 995–998.

Butler, E. E., Mueller, N. D., & Huybers, P. (2018). Peculiarly pleasant weather for US maize. Proceedings of the National Academy of Sciences of the United States of America, 115(47), 11935–11940.

Cao, Z. Y., Chen, Z. H., Tang, B., Zeng, Q., Guo, H. Le, Huang, W. H., Luo, Y., Shen, S., & Zhou, S. L. (2024). The effects of sowing date on maize: Phenology, morphology, and yield formation in a hot subtropical monsoon region. Field Crops Research, 309.

Das, C., Barik, A. K., & Mondal, K. (2020). Effect of zinc application on growth and yield of baby corn (Zea mays L.) in lateritic soil of West Bengal. International Journal of Chemical Studies, 8(2), 887–890.

Domokos, Z., Șimon, A., Chețan, F., Ceclan, O. A., Filip, E., Călugăr, R. E., Vâtcă, S. D., & Duda, M. M. (2024). The Influence of Sowing Date on the Primary Yield Components of Maize. Agronomy, 14(9).
Effendi, M., Nor, M., Othman, Z., Nordin, I., Ahmad, M., Salahuddin, H., Othman, A., Dzahirah Zulkafli, A., Samsudin, S., Towhid, M. F., Faris, M., Radzi, M., Syahman, A., Dalee, M., Hafizi, M., & Zamberi, M. (2021). Determination of harvest maturity of grain corn hybrid P4546 for better post-harvest quality. In Proceedings of MARDI Science and Technology Exhibition.
Erenstein, O., Jaleta, M., Sonder, K., Mottaleb, K., & Prasanna, B. M. (2022). Global maize production, consumption and trade: trends and R&D implications. In Food Security (Vol. 14, Issue 5, pp. 1295–1319). Springer Science and Business Media B.V.
FAO. 2024. Crops and livestock products. available online with updates at https://www.fao.org/faostat/en/#data/QCL. Assessed on 22-01-2025.
Habib-ur-Rahman, M., Ahmad, A., Raza, A., Hasnain, M. U., Alharby, H. F., Alzahrani, Y. M., Bamagoos, A. A., Hakeem, K. R., Ahmad, S., Nasim, W., Ali, S., Mansour, F., & Sabagh, A. EL. (2022). Impact of climate change on agricultural production; Issues, challenges, and opportunities in Asia. Frontiers in Plant Science, 13(925548), 01–22.
He, P., Ding, X., Bai, J., Zhang, J., Liu, P., Ren, B., & Zhao, B. (2022). Maize hybrid yield and physiological response to plant density across four decades in China. Agronomy Journal, 114(5), 2886–2904.
Ion, V., Dicu, G., Agrochemicals, P., Srl, R., Temocico, G., Gheorghe Basa, A., Dumbravă, M., Alecu, I. N., Gheorghe Băşa, A., & State, D. (2015). Harvest index at maize in different growing conditions. In Romanian Biotechnological Letters (Vol. 20, Issue 6).
Iqbal, M. A., Ahmad, Z., Maqsood, Q., Afzal, S., & Ahmad, M. M. (2015). Optimizing Nitrogen Level to Improve Growth and Grain Yield of Spring Planted Irrigated Maize (Zea mays L.). Journal of Advanced Botany and Zoology, 2(3), 1–4.
Kimmelshue, C. L., Goggi, S., & Moore, K. J. (2022). Seed Size, Planting Depth, and a Perennial Groundcover System Effect on Corn Emergence and Grain Yield. Agronomy, 12(2).
Kovalenko, O. A., Drobitko, A. V., Palamarchuk, V. D., & Bahliuk, U. P. (2023). Corn: Sowing Parameters. Journal of Organic and Pharmaceutical Chemistry, 20(4), 54–60.
Mali, G. R., Verma, A., & Malunjker, B. D. (2021). Effect of Different Post-emergence Herbicides Tank Mix with Atrazine on Nutrient uptake and Chlorophyll Content in Maize (Zea mays L.). Current Journal of Applied Science and Technology, 1–8.
Mueller, S. M., Messina, C. D., & Vyn, T. J. (2019). Simultaneous gains in grain yield and nitrogen efficiency over 70 years of maize genetic improvement. Scientific Reports, 9(1).
Omar, M., Rabie, H. A., Mowafi, S. A., Othman, H. T., El-Moneim, D. A., Alharbi, K., Mansour, E., & Ali, M. M. A. (2022). Multivariate Analysis of Agronomic Traits in Newly Developed Maize Hybrids Grown under Different Agro-Environments. Plants, 11(9).
Padjung, R., Bdr, M. F., Nasaruddin, N., Ridwan, I., Anshori, M. F., Abduh T, A. D. M., & Fachri, A. A. (2020). Growth and Production of Corn in Various Planting Distances Systems. Agrotech Journal, 5(2), 89–93.
Putri, N. D., Purqon, A., & Putra, R. E. (2023). Effect of Growth Space on The Productivity of Maize Using Three Sisters Cultivation with Bee Pollination. Jurnal Biodjati, 8(2), 191–202.
Rehman, A., Ma, H., Ozturk, I., & Ahmad, M. I. (2021). Examining the carbon emissions and climate impacts on main agricultural crops production and land use: updated evidence from Pakistan. Environmental Science and Pollution Research, 29, 868–882.
Rehman, F. U., Kalsoom, M., Adnan, M., Naz, N., Ahmad Nasir, T., Ali, H., Shafique, T., Murtaza, G., Anwar, S., & Arshad, M. A. (2021). Soybean mosaic disease (SMD): a review. Egyptian Journal of Basic and Applied Sciences, 8(1), 12–16.
Saleem, M. F., Randhawa, M. S., Hussain, S., Wahid, M. A., & Anjum, S. A. (2009). Nitrogen Management Studies in Autumn Planted Maize (Zea Mays L.) Hybrids. The Journal of Animal & Plant Sciences, 19(3), 140–143.
Sheldon, K., Shekoofa, A., McClure, A., Smith, A., Martinez, C., & Bellaloui, N. (2023). Effective irrigation scheduling to improve corn yield, net returns, and water use. Agrosystems, Geosciences and Environment, 6(4).
Steel, R.G.D., Torrie, J. H., & Dickey, D. A. (1997). Principles and Procedures of Statistics: A Biometrical Approach (3rd ed.). McGraw, New York.
Sudding, A. F., Maintang, Asri, M., Rauf, A. W., Syam, A., & Adriani W, A. (2021). The effect of NPK 15-15-6-4 compound fertilizer on corn growth and yield. IOP Conference Series: Earth and Environmental Science, 911(1).
Sun, S., Huang, Z., Liu, H., Xu, J., Zheng, X., Xue, J., & Li, S. (2023). Response of Grain Yield to Planting Density and Maize Hybrid Selection in High Latitude China—A Multisource Data Analysis. Agronomy, 13(5).
Villaver, J. P. (2020). Response of sweet corn (Zea mays L. var. saccharata) to vermicompost and inorganic fertilizer application. International Journal of Humanities and Social Sciences, 12(6), 17–27.
Viteri, D. M., & Linares-Ramírez, A. M. (2022). Timely Application of Four Insecticides to Control Corn Earworm and Fall Armyworm Larvae in Sweet Corn. Insects, 13(3).
Wu, W., Yue, W., Bi, J., Zhang, L., Xu, D., Peng, C., Chen, X., & Wang, S. (2024). Influence of climatic variables on

maize grain yield and its components by adjusting the sowing date. Frontiers in Plant Science, 15.

Yogi, L. N., Thalal, T., & Bhandari, S. (2025). The role of agriculture in Nepal’s economic development: Challenges, opportunities, and pathways for modernization. In Heliyon (Vol. 11, Issue 2). Elsevier Ltd.

Youssef, M. A., Strock, J., Bagheri, E., Reinhart, B. D., Abendroth, L. J., Chighladze, G., Ghane, E., Shedekar, V., Norman, N. R., Frankenberger, J. R., Helmers, M. J., Dan, D. B., Kladivko, E., Negm, L., Nelson, K., & Pease, L. (2023). Impact of controlled drainage on corn yield under varying precipitation patterns: A synthesis of studies across the U.S. Midwest and Southeast. Agricultural Water Management, 275.

Yuan, X., Li, S., Chen, J., Yu, H., Yang, T., Wang, C., Huang, S., Chen, H., & Ao, X. (2024). Impacts of Global Climate Change on Agricultural Production: A Comprehensive Review. In Agronomy (Vol. 14, Issue 7). Multidisciplinary Digital Publishing Institute (MDPI).