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EVALUATING THE PERFORMANCE OF KHARIF MAIZE VARIETIES WITH VARIABLE SOWING DATES IN EASTERN UTTAR PRADESH INDIA

Anurag Tripathi[1,2*], S.R. Mishra[1], Rajeev Ranjan[2], Neha Chand[2] and Shubham Pandey[1]
[1]Department of Agrometeorology, ANDUA&T, Kumarganj, Ayodhya, U.P., India
[2]Department of Agrometeorology, GBPUAT, Pantnagar, Uttarakhand, India
*Corresponding author E-mail: atagmet1110@gmail.com
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ABSTRACT

This study investigates the influence of different sowing dates and cultivars on the growth and yield of maize (*Zea mays* L.) during the kharif season of 2022 at the Student's Instructional Farm of Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya, U.P., India. Using a Split Plot Design (S.P.D.) with nine treatment combinations, the experiment examined three sowing dates (June 5th, June 15th and June 25th) and three maize cultivars (Kanchan, Sonari (Shweta) and AQH-04). The experimental field characterized by silt loam soil with an alkaline pH, exhibited notable improvements in plant height, dry matter accumulation and leaf area index (LAI) with the earliest sowing date of July 5th. The AQH-04 cultivar consistently recorded the tallest plants (204.40 cm) and the highest LAI and dry matter accumulation (1652.20 g/m²), outperforming Kanchan and Sonari. Yield-related characteristics, including the number of cobs per plant, cob length, number of grain rows per cob, number of grains per cob row, number of grains per cob, cob weight and test weight were maximized with the July 5th sowing date. In contrast, the lowest values for all these parameters were observed on July 25th. The study concludes that both the crop growing environment and the choice of cultivar substantially affect maize productivity. Early sowing on July 5th, coupled with the AQH-04 cultivar, resulted in superior growth metrics and yield, highlighting the importance of optimal sowing time and cultivar selection for maximizing maize production. These findings offer valuable insights for enhancing maize cultivation practices in similar agro-climatic conditions, emphasizing the role of precise agricultural management in achieving high yields.
***Keywords*:** Sowing date, Grain yield, Cultivar, Environment and Cob

Introduction

Maize, a member of the Poaceae family, ranks as the third most crucial cereal crop worldwide after wheat and rice. In India, it is highly valued in agriculture, alongside rice and wheat because of its fast growth, high yield potential, ease of cultivation, industrial uses and nutritional benefits. Known as the "Queen of Cereals" maize is celebrated for its adaptability to various environmental conditions and its exceptional production capacity (Choudhari & Channappagouda, 2015).

The top three uses of maize in the world are for feed (61%), food (17%), and industry (22%) as 83% of its production used in feed, starch and bio-fuel industries. Additionally, more than 3000 goods are produced directly or indirectly using maize, offering numerous opportunities for value addition. It is a major force behind the global agricultural economy due to its many uses (ICAR-Indian Institute of Maize Research, 2020-21).

Climate, soil, variety, and cultural practises all influence maize yield. Correlating these functions to produce the highest possible yields with the greatest efficiency has been the aim of research workers ever since the maize production began. Since there is a limited scope to increase the area under maize cultivation because of competition from other cereals and commercial crops, the only alternative is through enhancement of productivity by various management factors. Among the factors limiting yield of maize in many areas is inadequate irrigation and low plant population (Reddy, 2017).

Maize is a flexible crop since it may be cultivated in a variety of agroclimatic zones. In contrast to other crops, maize may be cultivated in a variety of environmental conditions. It is grown from 58°N to 40°S, from below sea level to altitudes higher than 3000 m, and in areas with 250 mm to more than 5000 mm of rainfall per year (AICRPM, 2007).

Over the past 40 years the total global area sown under maize has increased by about 40 per cent and production has doubled. The maize is cultivated throughout the year in all states of the country for various purposes including grain, fodder, green cobs, sweet corn, baby corn, pop corn in peri-urban areas. Currently, nearly 1147.7 million MT of maize is being produced together by over 170 countries from an area of 193.7 million ha with an average productivity of 5.75 t/ha. USA is the major producer of maize (31.08%), followed by China (23.42%), Brazil (9.27%), European Union (5.89%), Argentina (4.49%), Ukraine (3.22%), India (2.8%), Mexico (2.25%), South Africa (1.48%) and Others (16.45%) (Statistical yearbook, 2020).

In India Maize is cultivated in both kharif and rabi season. About 85% of the crop area is in the spring, summer and kharif seasons, and 15% in the winter (rabi) season. In India, the area of maize in 2020-21 was about 9.86 million hectares with a production of 31.51 million tons and productivity was 3195 kg/ha. The Major growing states contributing 85% of the total maize production are: Karnataka (16.45%), Madhya Pradesh (11.37%), Maharashtra (10.91%), Tamil Nadu (8.63%), West Bengal (7.76%), Rajasthan (7.20%), Bihar (7.06%), Andhra Pradesh (6.19%), Uttar Pradesh (5.72%), Telangana (5.55%), Others (13.15%) (Directorate of Economics and Statistics, 2021).

Maize is cultivated in a variety of conditions, but is most common in the warmer temperate zones and the humid subtropics. The ideal temperature for maize plants is between 22 and 32°C during the day and between 16.7 and 23.3°C at night. When the temperature drops below 5°C or increases over 32°C, plant growth is negatively impacted (Vanaja *et al*., 2017).

The critical agrometeorological variables associated with agricultural production are precipitation, air temperature and solar radiation. The growth rate and development of crops from planting to maturity is dependent mainly upon temperature. The temperature and solar radiation have greater effect on growth and development of crop. Shift in sowing dates directly influence both thermo and photoperiod and consequently a great bearing on the phasic development and partitioning of dry matter (Leelarani *et al*., 2012).

The variation in crop growing environment modifies the microclimate to which the plants are exposed which is responsible for biomass production and ultimately the yield. It is necessary to understand the knowledge of plant environment interaction for increasing the yield of crop. Phenological development of crop closely followed the changes in weather conditions occurring during crops growing period. The crop microclimate is affected by the crop growing environment, which directly affects plant growth, development, and resource utilisation (Hugar and Halikatti, 2015).

The extent to which soil temperature affects yield varies with sowing time and the latitude of growth location. Hence, there is a need to study the performance of maize grown in different environments as affected by changes in the sowing dates as well as identify suitable hybrids of contrasting duration to realise the higher yield of maize. In India it is commonly farmed as an important kharif crop in rainfed or irrigated condition so, it is a rainy season crop. However, the Kharif crop suffers due to the vagaries of the monsoon, excessive rainfall leading to water stagnation, poor drainage, erratic and insufficient rainfall leading to moisture stress condition, severe infestation of insect-pest-diseases, fertilizer losses, greater weed menace, and high temperatures throughout the growth period which tend to reduce grain yield in Kharif maize (Singh, 2013).

Material and Methods

The experiment took place at the Student's Instructional Farm of Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya (U.P.) during the kharif season of 2022. Located on the Faizabad-Raibareily road, about 42 km from the Ayodhya district headquarters, the farm is positioned at latitude 26° 54' N, longitude 81° 82' E and an altitude of 113 meters above sea level. This site is part of the Indo-Gangetic alluvium of Eastern Uttar Pradesh.

The experimental design applied was a Split Plot Design (S.P.D.) which involved nine treatment combinations. These combinations included three sowing dates: June 5th (G1), June 15th (G2) and June 25th (G3). Additionally, three cultivars were tested: Kanchan, Sonari (Shweta) and AQH-4.

According to triangular method of soil classification recognized by International Society of Soil Science, the soil of the field may texturally be classified as silty loam, while low in organic carbon, nitrogen, sulphur and phosphorus but medium in potash contents.

Plant height (cm), leaf area index, dry matter accumulation (g/m²), number of cobs per plant, cob length (cm), number of grain rows per cob, number of grains per cob row, weight of grains per cob (g), weight of cob (g), test weight (g), grain yield (kg/ha) and stover yield (kg/ha) were calculated for all treatments. The experimental data were statistically analysed using the analysis of variance (ANOVA) method as described by Panse and Sukhatme (1978). The significance of treatment effects was tested using the 'F' (variance ratio) test. Standard errors and critical differences (CD at 5%) were recorded to differentiate the treatment effects.

Results and Discussion

Plant height (cm): The plant height of maize was significantly influenced by different crop growing environments and cultivars at all growth stages (Table-1). Plants sown on July 5th were significantly taller at every stage compared to those planted on other dates, with the shortest plants observed from the July 25th sowing. Among the cultivars, AQH-04 produced the tallest plants (204.40 cm). This increased height could be due to higher plant density which reduces light availability to individual plants especially the lower leaves due to greater shading. At higher plant densities, plants tend to grow taller as mutual shading increases. These findings are consistent with the results of Kaur *et al.* (2019) and Sharma *et al.* (2020).

Table 1: Plant height (cm) of kharif maize cultivars as affected by crop growing environments

Treatment	Plant Height (cm)					
	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	At Harvest
Crop Growing Environment						
5th July **(32°C)**	**17.20**	**36.23**	**121.20**	**160.40**	**188.77**	**195.78**
15th July **(31.5 °C)**	16.87	35.47	116.37	154.03	181.20	187.94
25th July **(30.5 °C)**	16.50	34.80	111.73	147.87	173.93	180.43
SEm±	0.49	0.97	2.63	3.49	4.09	4.25
CD at 5 %	1.69	3.34	9.11	12.05	14.19	14.73
Cultivars						
Kanchan	16.47	33.90	109.93	145.47	171.13	173.74
Sonari (Shweta)	16.87	35.73	114.67	151.77	178.57	186.01
AQH- 04	**17.23**	**36.87**	**124.70**	**165.07**	**194.20**	**204.40**
SEm±	0.32	0.70	2.54	3.38	3.97	4.11
CD at 5 %	0.96	2.07	7.57	10.01	11.79	12.23

Leaf area index

Data on the leaf area index (LAI) of maize, influenced by crop growing environment and cultivars at various growth stages are presented (Table-2). The LAI steadily increased until 75 days after sowing (DAS) and then gradually declined until harvest due to leaf senescence. The highest LAI was observed in maize sown on July 5th, followed by July 15th, with the lowest LAI in the delayed sowing on July 25th. The AQH-04 variety consistently recorded significantly higher LAI at each growth stage compared to the other varieties. This increase in LAI can be attributed to higher plant density, resulting in more plants per unit area and consequently, more functional leaves. These findings align with the results of Abebe *et al.* (2016) and Vanaja *et al.* (2017).

Table 2: Leaf area index of Kharif maize cultivars as affected by crop growing environments

Treatment	Leaf Area Index				
	30 DAS	45 DAS	60 DAS	75 DAS	At harvest
Crop Growing Environment					
5th July **(32°C)**	**1.20**	**2.17**	**3.62**	**3.40**	**1.36**
15th July **(31.5 °C)**	1.17	2.04	3.40	3.20	1.28
25th July **(30.5 °C)**	1.15	1.93	3.22	3.03	1.21
SEm±	0.03	0.04	0.08	0.08	0.03
CD at 5 %	0.11	0.16	0.27	0.25	0.10

Cultivars					
Kanchan	1.12	1.84	3.08	2.89	1.15
Sonari (Shweta)	1.18	2.08	3.47	3.26	1.30
AQH- 04	**1.22**	**2.22**	**3.70**	**3.48**	**1.39**
SEm±	0.02	0.04	0.08	0.08	0.03
CD at 5 %	0.08	0.13	0.22	0.21	0.08

Dry matter accumulation

Data on dry matter accumulation at various growth stages are presented. The statistics clearly show that the crop growing environment significantly impacted dry matter accumulation at all stages (Table-3). The highest dry matter accumulation was observed in maize sown on July 5th, while the lowest was recorded for the July 25th sowing. The different varieties also significantly influenced dry matter accumulation at each stage. The AQH-04 variety consistently outperformed the other two varieties, with a dry matter accumulation of 1652.20 g/m². This higher dry matter production was attributed to greater plant height and increased LAI. These results are in agreement with the findings of Prasad *et al.,* (2017) and Dadapeer *et al*., (2020).

Table 3 : Dry matter accumulation (g/m^2) of Kharif maize cultivars as affected by crop growing environments

Treatment	**Dry Matter Accumulation (g/m^2)**			
	30DAS	**60DAS**	**90DAS**	**At harvest**
Crop Growing Environment				
5th July **(32°C)**	**193.00**	**1025.57**	**1367.40**	**1473.90**
15th July **(31.5 °C)**	189.13	954.17	1272.23	1371.57
25th July **(30.5 °C)**	185.37	900.53	1200.67	1294.27
SEm±	3.60	21.47	28.61	40.04
CD at 5 %	12.48	74.27	99.02	138.58
Cultivars				
Kanchan	181.33	1043.67	1391.57	1405.63
Sonari (Shweta)	188.77	770.90	1027.83	1081.90
AQH- 04	**197.40**	**1065.70**	**1420.90**	**1652.20**
SEm±	3.63	21.73	28.97	27.27
CD at 5 %	10.77	64.55	86.07	81.01

Yield Attributing Characters

Data on yield attributes and maize yield influenced by cultivars and growing environments are presented (Table 4). The crop growing environment had a significant impact on the number of cobs per plant, cob length (cm), number of rows per cob, number of grains per row, number of grains per cob, weight of cob, test weight and overall maize yield. Cultivars also had a substantial influence on all these yield characteristics as well as on maize yield. Sowing on July 5th consistently resulted in higher values compared to sowing on July 15th and 25th. Among the cultivars, AQH-04 consistently showed superiority over the other varieties in terms of yield qualities and overall maize yield.

Number of cobs per plant

The number of cobs produced per plant in Kharif maize was significantly influenced by the crop's growing environment (Table 4). Maize planted on July 5th showed a higher number of cobs per plant which was at par with 15th July while significantly over 25th July cultivars. The number of cobs per plant decreased as the plant population increased. Young kernel abortion that occurs right away after fertilisation is finally stimulated by the ear's restricted supply of carbon and nitrogen, according to Hemalatha *et al*., (2013).

Length of cob (cm)

The length of the cob in Kharif maize was notably influenced by the crop-growing environment. (Table 4). Maize planted on July 5th exhibited the longest cob length, which was at par to that of July 15th and significantly longer than those planted on July 25th. This could be attributed to better individual plant growth in lower density populations allowing for more efficient utilization of accumulated photosynthates that affect the growth and development of yield attributes. These findings align with the conclusions drawn by Hemalatha *et al.,* (2013).

No. of grains rows per cob

The number of grain rows per cob in Kharif maize was significantly influenced by the crop-growing environment (Table 4). Maize planted on July 5th showed the highest number of grain rows per cob, which was comparable to July 15th but significantly greater than those planted on July 25th. As plant density increased, the number of grain rows per cob tended to decrease. This decrease could be attributed to limited carbon and nitrogen supply to the ear, leading to early kernel abortion shortly after fertilization, as discussed by Shrestha *et al.* (2015).

No. of grains per cob row

The results (Table 4) show that the crop-growing environment had a substantial impact on the number of grains per row of Kharif maize. Regarding the crop-growing environment, the higher No of grains per row of maize was recorded with the crop growing environments 5th July which was at par with 15th July while significant over 25th July cultivars. As plant density decreases, the number of grains per row rises. With more frequent irrigation, there are more rows of grain because better root growth results in better nutrient uptake. Girijesh *et al*. (2011) reported similar outcomes.

No. of grains per cob

Table 4 show the number of grains per cob of Kharif maize as considerably influenced by crop growing environment. Regarding the crop-growing environment, the maize cultivars with the 5th July crop-growing environment recorded the largest number of grains per cob, significantly more than the 15th July and 25th July cultivars. Due to plant competition, the number of grains per cob reduces as plant population grows. Hemalatha *et al*. (2013) reported similar findings.

Table 4 : Yield attributes of kharif maize cultivars as affected by crop growing environments

Treatments	No. of cobs per plant	Length of cob (cm)	No. of grain rows per cob	No. of grains per cob row	No. of grains per cob
Crop Growing Environment					
5th July (**32°C**)	**1.79**	**19.20**	**16.53**	**30.73**	**511.04**
15th July (**31.5 °C**)	1.63	18.43	15.70	28.90	456.38
25th July (**30.5 °C**)	1.50	17.47	15.23	27.63	423.36
SEm±	0.04	0.41	0.36	0.66	10.86
CD at 5%	0.14	1.44	1.24	2.29	37.57
Cultivars					
Kanchan	1.46	16.63	14.53	25.37	369.21
Sonari (Shweta)	1.67	18.37	16.10	29.90	482.47
AQH-04	**1.79**	**20.10**	**16.83**	**32.00**	**539.47**
SEm±	0.04	0.40	0.34	0.64	9.62
CD at 5%	0.13	1.19	1.03	1.90	28.58

Yield:

Weight of cob: (g)

Cultivars and the crop growing environment have a considerable impact on the weight of the cob of Kharif maize (Table 5 and Fig.1). The 5th July crop growing environment had the highest weight of grains per cob of maize, which was much higher than cultivars grown on the 25th July. Due to inter-plant competition for light, water, nutrients and other potential production-limiting environmental factors dense plant populations had a negative impact on yield per plant. Dadapeer *et al*. (2020) reported the same outcomes.

Test weight: (g)

The environment of the crop growing has significant effects on the thousand seed weight of maize varieties (Table 5 and Fig.1). The 5th July had a greater thousand seed weight, which was comparable to the 15th July while being significantly higher than the 25th July cultivars. The development of yield attributes was impacted by the improved growth of individual plants in low density populations and the resulting utilisation of accumulated photosynthates. Test weight decreased as a result of increased competition among the plants for photosynthates brought on by higher population densities. Lower plant densities were used to attain the highest thousand seed weight. This result matches up with Dadapeer *et al.* (2020).

Grain yield: (kg ha^{1})

The impact of crop-growing environments on maize grain yield (Table 5 and Figure 1). Maize planted on July 5th and July 15th produced the highest grain yields, which were significantly greater than those from the July 25th planting, where the lowest yield was recorded. This difference can be attributed to the slower individual plant growth in higher population densities, resulting from increased mutual shading and greater interplant competition. As plant density rises, internal competition within plants intensifies between vegetative and reproductive parts. Changes in assimilate transport within plants may occur at higher densities, potentially leading to more barren plants and a critical period of light competition during grain formation. Similar conclusions were drawn by Shrestha *et al.* (2015) and Singh *et al.* (2021)

Stover yield: (kg ha^{1})

Different crop growing environments had a significant effect on maize stover yield. (Table 5 and Fig.1) On July 5th, a higher production of stover yield was observed in comparison to July 15th and July 25th crop-growing conditions. This produced the lowest output of stover yield. This is a result of enhanced plant growth, including plant height, leaf area and dry matter production, as well as increased plant density per unit area. Dadapeer *et al.* (2020) and Singh *et al.* (2021) both came to similar conclusions.

Table 5 : Yield of kharif maize cultivars as influenced by crop growing environments

Treatments	Weight of cob (g)	Test Weight (g)	Grain Yield (q ha ^{1})	Stover Yield (q ha ^{1})
Crop Growing Environment				
5th July (**32^{o}C**)	**178.37**	**216.60**	**51.57**	**95.82**
15th July (**31.5 ^{o}C**)	156.93	213.37	48.47	88.68
25th July (**30.5 ^{o}C**)	143.37	210.13	45.56	86.86
SEm±	3.79	4.87	1.20	2.32
CD at 5%	13.11	16.84	4.17	8.04
Cultivars				
Kanchan	118.00	199.60	49.51	91.06
Sonari (Shweta)	167.63	217.10	37.84	70.35
AQH-04	**193.03**	**223.40**	**58.26**	**106.96**
SEm±	3.67	4.63	1.12	2.03
CD at 5%	10.90	13.76	3.32	6.03

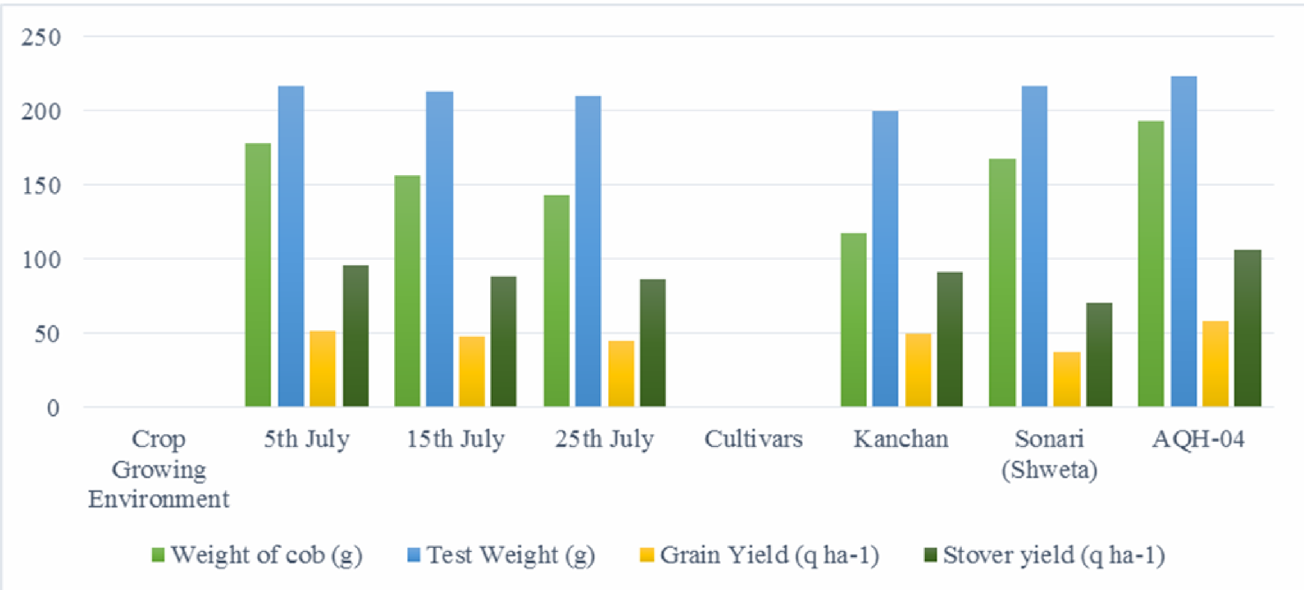

Fig. 1 : Yield of kharif maize cultivars as influenced by crop growing environments

Based on the experiment conducted on a silt loam soil with an alkaline pH (8.0), low organic carbon (0.34 Kg ha^{1}), and adequate nitrogen (173.20 Kg ha^{1}), medium phosphorus (16.02 Kg ha^{1}), and high potassium (239.53 Kg ha^{1}), several key observations were made regarding crop growth and yield characteristics. Throughout the stages of crop growth, including observations on July 5th, 15th, and 25th, significant increases were noted in plant height (cm), dry matter accumulation (g m^{2}), and leaf area index. Notably, the most favourable conditions for these parameters were observed on July 5th, followed by July 15th, with July 25th showing the least favourable outcomes.

On July 5th, crucial yield-related characteristics such as the number of cobs per plant, cob length (cm), number of grain rows per cob, number of grains per cob row, grains per cob, cob weight (g), and test weight (g) reached their peak levels. Conversely, these parameters were at their lowest on July 25th. Grain yield (kg ha^{1}) and stover yield (kg ha^{1}) followed a similar pattern, being highest on July 5th and comparatively lower on July 25th.

Conclusion

In conclusion, the experiment demonstrated that early growth stages in the crop-growing environment, particularly around July 5th, were most conducive to achieving maximum plant growth, yield-related characteristics, grain yield, and stover yield. The variations observed across different observation dates highlight the critical influence of environmental factors and growth stages on crop productivity in silt loam soils with the specified nutrient levels. These insights can guide future agricultural practices aimed at improving sustainability and efficiency in crop production systems.

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