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Chinmaya Kumar Sahu
Ph.D. Research Scholar, Department of Agrometeorology, GBPUA&T, Pantnagar, Uttarakhand, India

Ravi Kiran
Professor, Department of Agrometeorology, GBPUA&T, Pantnagar, Uttarakhand, India

Siddhant Gupta
Ph.D. Research Scholar, Department of Agrometeorology, GBPUA&T, Pantnagar, Uttarakhand, India

Naveen Kumar Bind
Ph.D. Research Scholar, Department of Agrometeorology, GBPUA&T, Pantnagar, Uttarakhand, India

Corresponding Author:
Chinmaya Kumar Sahu
Ph.D. Research Scholar, Department of Agrometeorology, GBPUA&T, Pantnagar, Uttarakhand, India

Optimizing sowing dates and nitrogen levels for enhanced maize yield and growth in kharif seasons over *Terai* region of Uttarakhand

Chinmaya Kumar Sahu, Ravi Kiran, Siddhant Gupta and Naveen Kumar Bind

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Abstract
This study evaluates the impact of different sowing dates and nitrogen fertilizer levels on the growth and yield of maize (variety DKC-9144) during the Kharif seasons of 2022 and 2023. A split-plot design was utilized with three sowing dates (June 27th , July 12th , and July 27th) as main plots and four nitrogen levels (0, 100, 150, and 200 kg/ha) as subplots, each replicated three times. Key agronomic parameters were measured, including the number of leaves, plant height, leaf area index, grain yield, stover yield, and harvest index. Data analysis included calculating the critical difference and standard error at a 5% significance level to assess the effects of sowing dates, nitrogen levels, and their interactions. Results indicate that the July 12th sowing date significantly enhanced growth parameters and yields, with pooled grain and stover yields of 8172 kg/ha and 9718 kg/ha, respectively. The highest nitrogen application (200 kg/ha) markedly improved all measured parameters, with pooled grain and stover yields reaching 9710 kg/ha and 11737 kg/ha, respectively. The interaction between sowing dates and nitrogen levels was not significant, suggesting independent effects on maize performance. In conclusion, for optimal growth and yield of maize variety DKC-9144, a mid-season sowing date (around July 12th) combined with a nitrogen application rate of 200 kg/ha is recommended. These findings provide critical insights for maize cultivation, optimizing productivity under similar agro-climatic conditions.

Keywords: Maize, sowing dates, nitrogen fertilizer, agronomic performance

1. Introduction
Maize (*Zea mays* L.) is a vital global crop, ranking third in agricultural production in India after rice and wheat. Its wide genetic variability allows for cultivation in various regions. In addition to being a major food and feed crop, maize serves multiple industries. In India, maize is predominantly used for poultry feed (over 47%), starch production (14%), food consumption (13%) and livestock feed (13%). Approximately 7% of maize is utilized in food processing, with around 6% allocated for export and other uses (IIMR, 2021) [10].
Historically, maize cultivation, production, and productivity showed an upward trend until the pre-green revolution era up to 1970. This was followed by a prolonged period of slow and static growth during the first two decades of the post-green revolution era. However, the past decade has seen a remarkable increase in the area under cultivation, as well as in the production and productivity of maize in India. Maintaining this growth is crucial to meet the rising demands for food, feed and industrial applications in the country. Globally, maize ranks as the third most important staple food crop in terms of area and production, following wheat and rice, but it holds the highest productivity, surpassing both. Currently, maize is cultivated on 205.8 million hectares worldwide, with a production of 1210.2 million metric tons and a productivity rate of 5.88 tons per hectare (FAOSTAT, 2021) [8].
In India, maize cultivation covers 9.86 million hectares, producing 31.6 million metric tons with a productivity rate of 3.2 tons per hectare during the 2020-21 period (FAOSTAT, 2021) [8]. India ranks fourth globally in maize cultivation area and seventh in production, contributing around 4% to the global cultivation area and 2% to global production. Among Indian states, Madhya

Pradesh and Karnataka have the largest maize cultivation areas, each accounting for 15%, followed by Maharashtra (10%), Rajasthan (9%) and Uttar Pradesh (8%), with other states contributing the rest. After Karnataka and Madhya Pradesh, Bihar is a notable maize producer, while Andhra Pradesh leads in state productivity (IIMR, 2021) [10].

Maize cultivation occurs in all three seasons: rainy (kharif), winter (rabi) and summer (spring), with various environmental, cultural and genetic factors affecting both productivity and quality (Kumari *et al*., 2017) [13]. The kharif season is the most dominant, accounting for approximately 83% of India's maize cultivation, while rabi maize makes up 17% (DACNET, 2020) [7]. Significant growth in spring maize production has been observed in the northwestern regions, particularly in Punjab, Haryana and Western Uttar Pradesh. This increase is due to fewer insects, pests, and diseases during spring, along with more sunshine hours. However, challenges such as high temperatures and limited water supply arise during the spring season. High temperatures affect both the vegetative and reproductive stages of maize, resulting in reduced grain filling. Therefore, effective irrigation water management is essential during the spring season due to high evapotranspiration (ET) levels (Sharma and Dass, 2012; Singh *et al*., 2016) [19, 21].

As a developing nation, India faces significant challenges in securing essential input resources such as fertilizer, mechanization, irrigation, pesticides, and high-quality seeds to maintain its agricultural production. Therefore, it is crucial to implement targeted strategies that include integrating organic and inorganic sources, adopting optimal tillage practices, and employing effective fertilizer management, among other measures. These strategies are designed to reduce production costs and preserve soil quality in the agricultural sector.

Maize, being a resource-intensive crop, requires substantial nutrition for its growth and development, with its productivity closely tied to effective nutrient management systems. Inorganic fertilizers are the predominant choice globally because they offer higher yields and more significant results. The efficient use of nitrogen is especially important for maize due to its high demand for this nutrient. Significant nitrogen input not only improves yield and economic returns but also reduces nitrate leaching into the soil (Asibi *et al*., 2020; Nduwimana *et al*., 2020) [4, 17]. However, commonly used fertilizers like urea, DAP, and MOP have shown lower efficiency, with nitrogen utilization rates ranging from 20 to 50% due to various losses. The use of nitrogen fertilizers is also linked to environmental pollution in agricultural areas, caused by processes such as ammonia volatilization, denitrification, and leaching (Ghosh *et al*., 2020) [9].

2. Materials and Methods

2.1 Site description

The study was conducted at the N.E. Borlaug Crop Research Center of G.B. Pant University of Agriculture and Technology, Pantnagar, situated in the Tarai belt at the foothills of the Shivalik range of the Himalayas in the Kumaon division at 29°3′ N latitude and 79°31′ E longitude, with an average altitude of 243 m (Figure 1). Pantnagar, located in Udham Singh Nagar district, serves as the primary food-producing region of Uttarakhand State, experiencing two major cropping seasons, namely Kharif and Rabi. The predominant crops in the region include rice, wheat, sugarcane, mustard, and soybean.

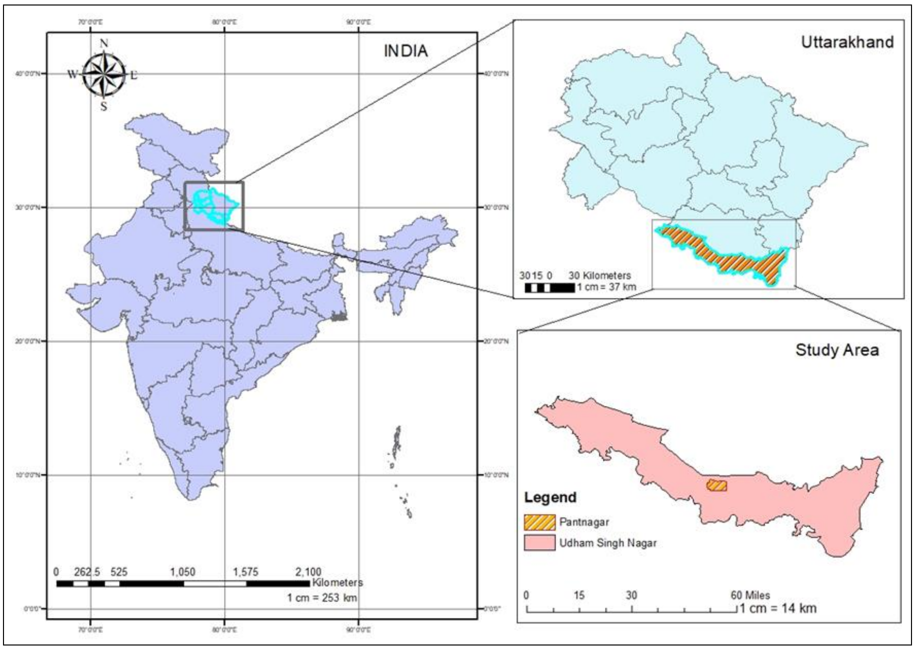

Fig 1: Location map of the experimental site

2.2 Experiment details

The experiment was conducted during the Kharif seasons of 2022 and 2023 to evaluate the performance of the maize variety DKC-9144. The study utilized a split-plot design, with the main plot factor being the Date of Sowing (DOS) and the sub-plot factor being different levels of Nitrogen fertilizer application. The experiment comprised 12 treatments (3 DOS x 4 Nitrogen levels), replicated thrice, resulting in 36 experimental plots. Sowing dates were strategically selected as D1: June 27, D2: July 12, and D3: July 27 and nitrogen levels were F1: 0 kg/ha, F2: 100 kg/ha, F3: 150 kg/ha, and F4: 200 kg/ha for both years. Each plot measured 26.4 m² (5.5 m x 4.8 m), with rows spaced 60 cm apart and plants spaced 25 cm within rows, ensuring optimal plant density. The experimental site featured silty loam soil, conducive to maize growth. This meticulous experimental setup aims to provide insights into the optimal sowing dates and nitrogen fertilizer levels for enhancing maize yield under the given agro-climatic conditions.

2.3 Data collection
Data collection focused on key agronomic parameters, including the Leaf Area Index (LAI), which was measured using a ceptometer. Additional data collected included the number of leaves per plant and plant height at maturity. Yield-related parameters were meticulously recorded, encompassing grain yield, stover yield, and harvest index. Statistical analysis was performed on all collected data, calculating the critical difference and standard error at a 5% level of significance to evaluate the effects of sowing dates, nitrogen levels, and their interaction. This rigorous analysis aimed to discern significant differences and interactions among the treatments, providing a robust understanding of how these factors influence maize performance.

3. Results and Discussion
3.1 Number of leaves, plant height and Leaf area index
The results presented in Table 1 demonstrate the influence of different sowing dates on maize agronomic parameters across 2022 and 2023. It is evident that the sowing date had a significant impact on the number of leaves, plant height, and leaf area index. Maize sown on July 12 (D2) exhibited the highest number of leaves and leaf area index consistently across both years, with pooled values of 24.54 leaves and a leaf area index of 4.72. Additionally, this sowing date resulted in the tallest plants, with a pooled height of 197.7 cm. In contrast, the earliest sowing date (June 27, D1) produced slightly fewer leaves and a lower leaf area index, although it still supported considerable growth with a pooled leaf area index of 4.13. The latest sowing date (July 27, D3) yielded intermediate results, indicating that mid-season sowing provided the most favorable conditions for maize growth in this experiment. These findings are in line with the findings of Berzsenyi *et al*. (1998) [5], Khosravani *et al*. (2017) [12] and Maresma *et al*. (2019) [15].

Regarding nitrogen application, the data clearly show a positive correlation between increased nitrogen levels and all measured growth parameters. The application of 200 kg/ha of nitrogen (F4) resulted in the highest number of leaves, tallest plants, and greatest leaf area index across both years, with pooled values of 24.78 leaves, 191.34 cm plant height, and a leaf area index of 5.66. This trend was consistent, with incremental increases in nitrogen leading to proportional increases in all parameters. Even the lowest nitrogen application (0 kg/ha, F1) supported a reasonable level of growth, but the substantial differences highlighted by the highest nitrogen levels underscore the importance of sufficient nitrogen fertilization in optimizing maize growth. These findings are similar to the findings of Amin *et al*. (2011) [2], Arif *et al*. (2010) [3], and Alam *et al*. (2020) [1].

The interaction effects of sowing dates and nitrogen levels on the measured parameters were not statistically significant, as indicated by the non-significant (NS) values across all parameters and years. This suggests that while both sowing date and nitrogen application independently influence maize growth, their combined effect does not significantly alter the outcomes beyond what is observed individually. Consequently, the optimal conditions for maize growth can be determined by considering sowing date and nitrogen levels separately rather than relying on their interaction, simplifying decision-making for farmers aiming to maximize maize yield under similar agro-climatic conditions.

Table 1: Number of leaves, plant height (cm) and leaf area index as influenced by date of sowing and nitrogen levels during 2022 and 2023

Treatments	Number of leaves (60 DAS)			Plant Height (at maturity)			Leaf area index (80 DAS)		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
Dates of sowing									
D1: 27 June	23.5	23.33	23.79	185.19	174.42	179.84	4.33	3.93	4.13
D2: 12 July	25.08	25.08	24.54	199.11	196.26	197.7	4.72	4.72	4.72
D3: 27 July	24	23.75	23.92	175.77	186.7	1811.27	4.01	4.25	4.13
SE (m) ±	0.28	0.28	0.21	0.76	0.67	0.57	0.07	0.05	0.02
CD (P = 0.05)	1.13	1.13	NS	3.07	2.77	2.31	0.26	0.22	0.07
Nitrogen application									
F1: 0 kg/ha	23	22.78	23.22	181.56	181.29	181.46	1.75	1.91	1.83
F2: 100 kg/ha	23.78	23.78	23.89	184.46	183.98	184.24	4.63	4.39	4.52
F3: 150 kg/ha	24.67	24.44	24.44	188.81	187.21	188.03	5.35	5.24	5.3
F4: 200 kg/ha	25.33	25.22	24.78	191.93	190.7	191.34	5.68	5.64	5.66
SE (m) ±	0.39	0.45	0.25	1.48	1.44	0.72	0.16	0.12	0.09
CD (P = 0.05)	1.18	1.34	0.76	4.43	4.3	2.15	0.33	0.32	0.26
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS

3.2 Grain yield, stover yield and harvest index
The results in Table 2 illustrate the effects of different sowing dates on grain yield, stover yield, and harvest index of maize during the 2022 and 2023 seasons. Maize sown on July 12 (D2) consistently achieved the highest grain yield, with pooled values of 8172 kg/ha, and stover yield, with pooled values of 9718 kg/ha. Additionally, this sowing date resulted in a slightly higher harvest index (0.49), indicating a better proportion of grain to total biomass. In contrast, the earliest sowing date (June 27, D1) produced a lower grain yield (pooled 7497 kg/ha) and stover yield (pooled 9085 kg/ha) with a harvest index of 0.48. The latest sowing date (July 27, D3) yielded the lowest grain and stover yields among the three dates but still maintained a competitive harvest index of 0.48. These results underscore the advantage of mid-season sowing for maximizing yield and harvest efficiency. The findings of this study are correspondence to results of Kharazmshahi *et al*. (2015) [11], Shrestha *et al*. (2015) [20] and Parker *et al*. (2016) [18].

Nitrogen application significantly influenced all measured parameters, with higher nitrogen levels resulting in increased grain and stover yields and improved harvest index. The highest nitrogen application rate (200 kg/ha, F4) produced the greatest grain yield (pooled 9710 kg/ha) and stover yield (pooled 11737 kg/ha) with a harvest index of 0.49. This trend was evident across both years, highlighting the critical role of nitrogen in enhancing maize productivity. Even at lower application rates, such as 150 kg/ha (F3), substantial yields were achieved, indicating a positive response to nitrogen fertilization. The lowest nitrogen application (0 kg/ha, F1) resulted in significantly lower yields (pooled grain yield 3840 kg/ha, stover yield 5181 kg/ha) and a lower harvest index of 0.46, emphasizing the necessity of adequate nitrogen supply for optimal crop performance. Similar results on these parameters were reported by Biswas and Ma (2016) [6], Liang *et al*. (2015) [14] and Moser *et al*. (2006) [16].

The interaction effects of sowing dates and nitrogen levels on grain yield, stover yield, and harvest index were not statistically significant, as indicated by the non-significant (NS) interaction terms. This suggests that the influence of sowing date and nitrogen level on maize productivity operates independently rather than synergistically. Consequently, the optimal grain and stover yields can be achieved by considering the effects of sowing date and nitrogen application separately. This finding simplifies the decision-making process for farmers, who can focus on optimizing each factor individually to maximize maize yields under similar agro-climatic conditions.

Table 2: Grain yield (kg/ha), stover yield (kg/ha) and harvest index as influenced by date of sowing and nitrogen levels during 2022 and 2023

Treatments	Grain Yield			Stover Yield			Harvest index		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
Dates of sowing									
D1: 27 June	7460	7533	7497	9483	8687	9085	0.51	0.46	0.48
D2: 12 July	8184	8159	8172	9959	9477	9718	0.52	0.46	0.49
D3: 27 July	6781	7881	7331	8763	9395	9079	0.5	0.45	0.48
SE (m) ±	175	199	120	121	143	60	0.002	0.006	0.004
CD (P = 0.05)	707	NS	485	487	576	85	0.01	0.02	0.01
Nitrogen application									
F1: 0 kg/ha	3765	3915	3840	5107	5255	5181	0.49	0.43	0.46
F2: 100 kg/ha	7938	8186	8062	10301	8977	9639	0.5	0.48	0.49
F3: 150 kg/ha	8857	9251	9054	10738	10499	10619	0.52	0.47	0.5
F4: 200 kg/ha	9340	10080	9710	11462	12013	11737	0.52	0.46	0.49
SE (m) ±	155	191	125	251	149	148	0.006	0.008	0.006
CD (P = 0.05)	466	572	373	750	445	443	0.02	0.02	0.02
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS

4. Conclusion

The results of this study provide comprehensive insights into the effects of sowing dates and nitrogen levels on the agronomic performance and yield of maize (variety DKC-9144) during the Kharif seasons of 2022 and 2023. The findings indicate that the sowing date of July 12th consistently resulted in the highest number of leaves, plant height, leaf area index, grain yield, and stover yield, establishing it as the optimal sowing date among those tested. In terms of nitrogen application, the highest level of 200 kg/ha significantly enhanced all measured growth parameters and yields, demonstrating the critical importance of adequate nitrogen fertilization for maximizing maize productivity. Importantly, the interaction effects between sowing dates and nitrogen levels were not statistically significant, suggesting that these factors influence maize growth and yield independently. In conclusion, for the variety DKC-9144, a mid-season sowing date around July 12th, combined with a nitrogen application rate of 200 kg/ha, is recommended to achieve optimal growth and yield outcomes. These findings provide valuable guidance for maize growers aiming to optimize their crop management practices under similar agro-climatic conditions, thereby enhancing productivity and efficiency.

5. References

1. Alam MM, Salahin N, Islam S, Begum RA, Hasanuzzaman M, Nahar K. Effect of tillage practices on soil properties and crop productivity in maize cultivation. Agric Res. 2020;9:123-132. https://doi.org/10.1007/s40003-019-00430-3
2. Amin R, Hussain S, Ahmad N. Effect of integrated nutrient management on growth and yield of maize (*Zea mays* L.). J Agric Res. 2011;49(1):65-70.
3. Arif M, Ali S, Tahir M. Integrated use of organic and inorganic fertilizers in maize (*Zea mays* L.). Pak J Agric Sci. 2010;47(2):65-70.
4. Asibi AE, Chai Q, Coulter JA. Mechanisms of nitrogen use in maize. Agronomy. 2020;10(3):447. https://doi.org/10.3390/agronomy10030447
5. Berzsenyi Z, Györffy B, Lap DQ. Effect of crop rotation and fertilization on maize yields and efficiency of nutrient utilization. Acta Agronomica Hungarica. 1998;46(3):219-228.
6. Biswas S, Ma BL. Effect of nitrogen application on nitrogen use efficiency and yield of maize under different tillage practices. Can J Plant Sci. 2016;96(3):386-393. https://doi.org/10.1139/cjps-2015-0310
7. DACNET. Directorate of Maize Research Annual Report 2019-20. Directorate of Maize Research; 2020.
8. FAOSTAT. Food and Agriculture Organization of the United Nations. Available from: http://www.fao.org/faostat/en/#home. Accessed 2021.
9. Ghosh A, Saha S, Ray R. Nitrogen losses from urea in rice-maize cropping system: An overview. Agric Res. 2020;9:102-110. https://doi.org/10.1007/s40003-019-00429-w
10. IIMR. Indian Institute of Maize Research. Available from: http://iimr.icar.gov.in/. Accessed 2021.
11. Kharazmshahi E, Esmaeilian Y, Rahimi A. The effect of different levels of nitrogen and plant density on maize yield and its components. Int J Agric Crop Sci. 2015;8(3):321-328.
12. Khosravani A, Sadeghi-Shoae M, Zare M. The effects of nitrogen levels and timing on maize yield and nitrogen efficiency. J Plant Nutr. 2017;40(3):420-429. https://doi.org/10.1080/01904167.2016.1202982
13. Kumari P, Singh SP, Rai V. Climate change impacts on maize production and its adaptation strategies in India: A review. Curr Agric Res J. 2017;5(1):1-13. https://doi.org/10.12944/CARJ.5.1.01
14. Liang X, Chen Y, Xiao H. Effect of nitrogen fertilization on maize yield and nitrogen use efficiency in Northeast China. Field Crops Res. 2015;183:108-115. https://doi.org/10.1016/j.fcr.2015.07.018
15. Maresma A, Torres M, Martínez C. Impact of nitrogen

application strategies on yield and nitrogen use efficiency in maize. Agron J. 2019;111(4):1641-1651. https://doi.org/10.2134/agronj2018.06.0425

16. Moser SB, Feil B, Jampatong S. Effects of pre-anthesis drought, nitrogen fertilizer rate, and variety on grain yield, yield components and harvest index of tropical maize. Agric Water Manage. 2006;81(1-2):41-58. https://doi.org/10.1016/j.agwat.2005.04.006
17. Nduwimana G, Traore S, Somé K. Nitrogen use efficiency in maize production in the western region of Burkina Faso. Int J Plant Soil Sci. 2020;32(4):1-10. https://doi.org/10.9734/ijpss/2020/v32i430291
18. Parker M, Bhattarai S, Payero J. The impact of different nitrogen application rates on maize yield and nitrogen use efficiency in a semi-arid environment. Agric Water Manage. 2016;177:36-44. https://doi.org/10.1016/j.agwat.2016.06.020
19. Sharma P, Dass S. Water management in spring maize. Indian J Agron. 2012;57(2):98-102.
20. Shrestha J, Deb P. Effect of nitrogen and plant density on maize yield in Chitwan, Nepal. J Maize Res Dev. 2015;1(1):112-122. https://doi.org/10.3126/jmrd.v1i1.14243
21. Singh B, Goyal M, Kapoor R. Impact of heat stress on the productivity of maize crop in India. J Agric Sci. 2016;8(5):123-133. https://doi.org/10.5539/jas.v8n5p123