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IMPACT OF NITROGEN LEVELS AND VARIETIES ON GROWTH AND FODDER YIELD OF MAIZE

RAHUL BANIK, NAVNIT KUMAR[1], GANGADHAR NANDA, BARSHA MANSINGH, PRANJEET KALITA, SUMIT SOW*, SHIVANI RANJAN, MAHMOUD F SELEIMAN[2] AND MUHAMMAD NAZIM[3,4]

Department of Agronomy, Dr. Rajendra Prasad Central Agricultural University, Pusa 848125 Bihar, India

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Abstract

A field experiment was performed at the forage research plot of Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar, India, during the winter season of 2022-23 to study the impact of different nitrogen levels and varieties on growth and fodder yield of maize varieties. The study was carried out in split plot design with three nitrogen levels in main plots (150, 180 and 210 kg/ha) and five maize varieties (NK 7550, NK 7328, NK 7660, J 1006 and Shaktiman-5) in sub plots with three replications. The results showed that J 1006 had the tallest plants (209.7 cm) and leaf : stem ratio (0.63); Shaktiman-5 had the widest internode diameter (38.3 mm) and J 1006 had the maximum total above-ground dry matter accumulation per plant (170.5 g). Regarding fodder yield, J 1006 surpassed other varieties, producing the highest green fodder yield (89.8 t/ha) and dry fodder yield (21.1 t/ha), except for NK 7660 and Shaktiman-5.

Introduction

Maize (*Zea mays* L.) is also the third-most significant grain crop and can tolerate a variety of soil and climatic conditions (Ali and Anjum 2017). During the year 2020-2021, the gross value added (GVA) contribution of the agricultural and allied sector to the overall economy is 20.2% (MoSPI 2023). Now, there are around 400.6 million tonnes of green fodder and 466 million tonnes of dry fodder available, which are on average less than half of need. As dairy farming plays an important role in the food supply chain, ensuring a consistent supply of high-quality fodder is critical for dairy farmers (Banik *et al.* 2023). Currently, the nation has a net shortfall in concentrate feed materials, green fodder and dry fodder of 44, 35.6 and 10.9%, respectively (IGFRI Vision 2050). The year-round availability of green fodder for livestock is a major problem in the country. Being a C_4 type of plant, maize is a great option in terms of higher fodder production in a shorter duration. The acceptability of maize as fodder is high as it is free from any anti-nutritional compounds like nitrates, oxalates, alkaloids and mycotoxins. It has a high protein percentage (8-11%) and possesses high dry matter digestibility (52-68%) (Mahanta *et al*. 2023). In India, just 13% of the entire amount of maize produced is used as animal feed and the area under fodder is very less. Therefore, there is a need for high biomass-producing maize varieties and their production strategies to fulfil the ever-increasing demand for fodder purposes (Roy *et al*. 2023).

*Author for correspondence: <sumitsow19@gmail.com>. [1]Sugarcane Research Institute, Dr. Rajendra Prasad Central Agricultural University, Pusa 848125 Bihar, India. [2]Department of Plant Production, College of Food and Agriculture Sciences, King Saud University, P.O. Box 2460, Riyadh 11451, Saudi Arabia. [3]State Key Laboratory of Desert and Oasis Ecology, Key Laboratory of Ecological Safety and Sustainable Development in Arid Lands, Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences, Urumqi 830011 China. [4]University of Chinese Academy of Sciences, Beijing 100049 China.

Proper crop nutrition is crucial among other agronomic techniques to increase forage productivity and improve the quality of the feed. Nitrogen is one of the essential plant elements that is essential for both qualitative and quantitative improvements in fodder production (Sahoo *et al.* 2024). Nitrogen fertilization not only increases the quality of maize, particularly its crude protein content but also influences the fodder yield. It is found that adding nitrogen to maize enhances the fodder's nutritional value by raising the amount of crude protein (Singh and Verma 2023) and lowering the amount of ash and fibre. Hence, an experiment was conducted to assess the optimum nitrogen level and its potential positive effects on various physiological and fodder yield parameters on different maize varieties.

Materials and Methods

The research study was conducted at the forage research field of TCA, Dholi, a sub-campus of Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar, during the winter season of 2022-23. The experimental site is positioned at a latitude of 25º98' N and longitude of 85º60' E at a height of 52.2 m above mean sea level. The average annual rainfall in this region measures around 1200 mm, with the majority, approximately 941 mm (about 70% of the total rainfall), occurring between July and September. The crop received 0.25 mm rainfall during the growing season (Fig. 1). The experiment was laid out in a split-plot design with fifteen different treatments replicated three times. The treatments consisted of three levels of nitrogen application (150, 180 and 210 kg/ha) in the main plots, and five varieties of maize (NK 7550, NK 7328, NK 7660, J 1006 and Shaktiman-5) in the sub plots. Maize varieties were sown at a spacing of 40 × 20 cm keeping a seed rate of 50 kg/ha on October 28, 2022. Before sowing, half of the nitrogen required was applied, along with the full amounts of phosphorus and potassium. Then, at knee high stage, the remaining portion of nitrogen was applied. The nitrogen source used for fertilization was urea, while diammonium phosphate was used as the source for phosphorus and muriate of potash served

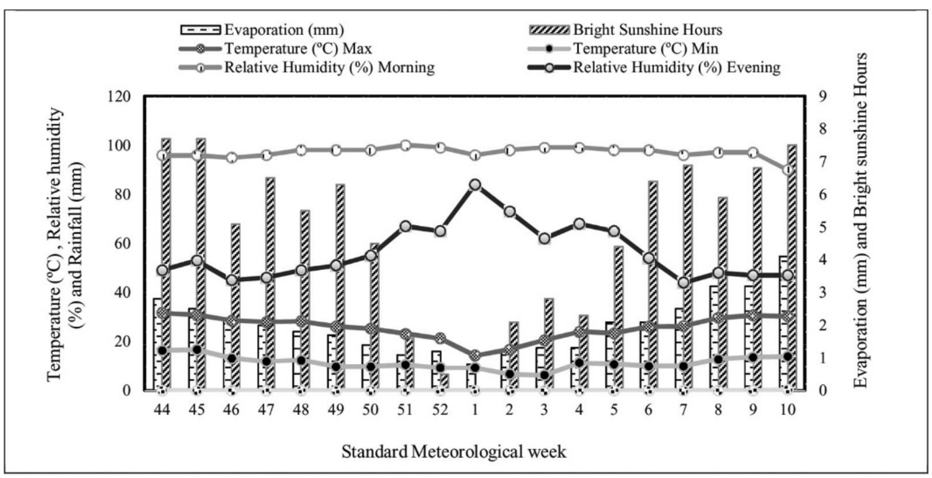

Fig. 1. Standard meteorological week wise meteorological data during the experimental period.

as the source for potassium. All other cultural operations were carried out following the standard package of practices. The crop was harvested manually when it attained soft dough stage. The crop yield from each net plot was harvested and weighed using an electronic weighing machine, and the yield was recorded in kg/plot. These values were subsequently converted to t/ha. Additionally, a known amount sample of green fodder was taken from each plot and these samples were placed in a hot air oven until a constant weight was reached. This process was carried out to determine the dry matter content of the fodder. Statistical analysis was done using the 'Analysis of Variance (ANOVA)' technique, following the methodology described by Gomez and Gomez (1984). To compare the means of different treatments, the critical difference (CD) was calculated at a significance level of 5%.

Results and Discussion

Plant height serves as a crucial parameter for assessing the growth and vigour of plants, playing a significant role in determining their vegetative characteristics. Across various crop growing stages, the application of 210 kg/ha of nitrogen consistently led to the highest plant height, a trend that was statistically comparable to the plant height achieved with 180 kg/ha at 60 Days aft4er sowing (DAS) (Table 1). Nitrogen noticeably influenced the physiology and metabolism of plants, which accelerated cell division and cell elongation. Similar results were also documented in studies conducted by Ali and Anjum (2017). Among the varieties, NK 7550 displayed the highest plant height (44.1 cm) at 30 DAS. Conversely, J 1006 exhibited the highest plant height from 60 DAS to harvest stage which was comparable to NK 7550, but significantly surpassing rest of the varieties (Table 1). The upward trend in plant height persisted until the harvest stage, with the growth rate accelerating notably after 30 DAS, coinciding with the transition from vegetative to reproductive phases and potential temperature-related influences. Comparable observations on significant variations in plant height across distinct maize varieties were also reported by Singh and Verma (2023).

Table 1. Effect of different nitrogen levels and varieties on plant height and number of leaves of maize.

Treatments	Plant height (cm)				Number of leaves/plants			
	30 DAS	60 DAS	90 DAS	Harvest	30 DAS	60 DAS	90 DAS	Harvest
N levels (kg/ha)								
150	39.6	99.5	140.7	178.6	6.4	9.1	11.6	11.9
180	41.3	102	141.4	187.5	6	10	11.8	12
210	43.8	105.3	157.1	192.6	6.4	10.5	12.7	13.2
SEm±	1.1	1.1	1.3	3.5	0.2	0.3	0.1	0.2
CD (*p*=0.05)	NS	4.4	5.2	NS	NS	NS	0.3	0.9
Varieties								
NK 7550	44.1	108.6	153.7	193.5	6.3	9.7	12.7	13
NK 7328	43.8	100.5	145.4	186.8	6.4	10.2	11.8	13.3
NK 7660	37	95.7	137.7	173	6	9.8	11.9	11.4
J 1006	43.8	113.8	162.7	209.7	6.4	9.8	12.2	12.2
Shaktiman-5	38.9	92.9	132.6	168.1	6.2	10	11.6	11.9
SEm±	1.5	2.4	3.2	4.8	0.1	0.2	0.2	0.3
CD (p≤0.05)	4.3	7.1	9.2	14	NS	NS	0.7	0.7
Interaction	NS	NS	NS	NS	NS	NS	NS	NS

NS: Non-significant and S: significant.

Information regarding the number of leaves/plants was collected at consistent intervals throughout various stages of crop growth, including 30, 60 and 90 DAS as well as during harvest (Table 1). The application of 210 kg/ha of nitrogen led to a higher number of leaves per plant which was 7.6 and 9.1% higher as compared to 180 kg/ha of N at 90 DAS and during harvest respectively. Conversely, the lowest number of leaves per plant was observed with 150 kg/ha of nitrogen. Similar observations were echoed by Shehzadi *et al.* (2024), who demonstrated a noticeable increase in leaf number with higher nitrogen doses. Thus, the number of leaves exhibited a pronounced rise with elevated nitrogen levels. Certainly, different varieties exhibited a noticeable influence on the number of leaves/plants at 90 DAS and during harvest. The highest number of leaves/plants was observed in variety NK 7550, statistically comparable to J 1006 at 90 DAS. Similarly, at the time of harvest, the maximum number of leaves/plants (13.3) was reported in NK 7328, which was on par with NK 7550. In contrast, Shaktiman-5 at 90 DAS and NK 7550 at harvest displayed the minimum number of leaves/plants. In plant growth, the number of leaves per plant plays a pivotal role as it facilitates the supply of food materials synthesized during photosynthesis. This fluctuation in leaf count directly contributes to the green fodder yield of fodder crops.

Table 2. Effect of different nitrogen levels and varieties on internode diameter and SPAD value of maize.

Treatments	Internode diameter (mm)				SPAD			
	30 DAS	60 DAS	90 DAS	Harvest	30 DAS	60 DAS	90 DAS	Harvest
N levels (kg/ha)								
150	6.5	20.3	25.3	178.6	46.8	53.6	53	48.9
180	7.3	21	26.5	187.5	47	54.4	55	49.2
210	7.4	21.6	27.7	192.6	48.6	55.4	56.4	50.6
SEm±	0.2	0.2	0.5	3.5	0.5	0.2	0.3	0.6
CD (*p*=0.05)	0.6	0.8	1.8	NS	NS	0.9	1.1	NS
Varieties								
NK 7550	8.3	20.6	26	36.4	46.8	53.6	53	48.9
NK 7328	6.5	20.8	25.7	36.2	47	54.4	55	49.2
NK 7660	6.2	21.4	27.2	38	48.6	55.4	56.4	50.6
J 1006	6.7	21	27	36.2	0.5	0.2	0.3	0.6
Shaktiman-5	7.7	21	26.7	38.3	NS	0.9	1.1	NS
SEm±	0.1	0.2	0.4	0.4	46.8	53.6	53	48.9
CD ($p \leq 0.05$)	0.3	0.9	1.1	1.3	47	54.4	55	49.2
Interaction	NS	S	NS	NS	48.6	55.4	56.4	50.6

NS= Non Significant, S=Significant.

Applying 210 kg/ha of nitrogen led to an increased internode diameter, which was statistically similar to the internode diameter at 180 kg/ha at 30, 60 and 90 DAS (Table 2). Whereas, it was significantly higher than 180 and 150 kg/ha at harvest. A significant increase in stem girth was also found with applying higher dose of nitrogen. Similar kind of result was also reported by Ochieng *et al.* (2023). At 30 DAS, the maximum internode diameter (7.4 mm) was found in NK 7550, which was significantly higher than all the other varieties. However, lowest internode diameter was observed in NK 7660 at 30 DAS. Whereas at 60 and 90 DAS, variety NK 7660 showed significantly higher internode diameter which was 8.1 and 4.7%, respectively higher as compared to NK 7328. These difference in internode diameter among the varieties maybe due to the genetic traits of the particular varieties. Adam *et al.* (2024) also reported similar kind of result that different varieties shows different internode diameter among their growing stages.

The SPAD readings exhibited significant variations across different nitrogen doses throughout the various stages of crop growth (Table 2). Notably, applying 210 kg/ha of nitrogen resulted in substantially higher SPAD readings compared to other nitrogen levels at 30, 60, 90 DAS and during harvest. This increase was particularly pronounced when compared to applying 150 and

180 kg N/ha. Conversely, the application of 150 kg/ha of nitrogen yielded the lowest SPAD reading at all stages of crop growth. These trends indicate a positive correlation between nitrogen levels and SPAD readings, suggesting that as nitrogen levels increased, the SPAD readings also demonstrated a corresponding increase to a certain extent (Sow *et al*. 2023). At 30 DAS, Shaktiman-5 had the maximum SPAD reading (48.9), which was significantly higher over all the other varieties but statistically at par with J 1006, whereas, NK 7660 had the lowest SPAD reading. At 60 DAS, J 1006 showed a higher SPAD value compared to other varieties but was statistically similar with NK 7660, whereas, NK 7328 showed the lowest SPAD reading. At the time of harvest, J 1006 showed highest SPAD reading, which was significantly higher than NK 7550 and NK 7328. This could be attributed to specific genetic characteristics that enhanced photosynthesis, leading to different SPAD readings. Lie *et al.* (2022) observed that there was a correlation between chlorophyll concentration and the rate of net photosynthesis.

Throughout all stages of crop growth, the accumulation of dry matter displayed notable variations due to the influence of various nitrogen doses. Notably, the application of 210 kg/ha of nitrogen resulted in significantly higher dry matter accumulation compared to other nitrogen doses at 30, 60, 90 DAS and during harvest. Conversely, the lowest dry matter accumulation was observed with the application of 150 kg/ha of nitrogen across all growth stages. This trend indicates that as the nitrogen dose increased, there was a corresponding rise in dry matter accumulation. This increase can be attributed to factors such as elevated leaf count, increased plant height, enhanced photosynthesis, and the synthesis of additional nutrients. Together, these factors contribute to the overall augmentation of dry matter. Distinct genotypes exhibited notable variation in total above-ground dry matter across all stages of crop growth. Specifically, at 30 DAS, the variety J 1006 demonstrated the highest accumulation of dry matter (5.1 g), significantly surpassing NK 7328 and NK 7660, while remaining statistically equivalent to NK 7550 and Shaktiman-5 (Table 3). However, certain variations in total above-ground drymatter accumulation can be attributed to a combination of genetic diversity and the influence of macro and micro environmental factors. The intricate interplay between these factors contributes to the observed differences in drymatter accumulation across different genotypes and growth stages (Nisar *et al.* 2024).

The leaf: stem ratio (LSR) quantifies the relative proportion of leaves to stems within a plant. Applying 210 kg/ha of nitrogen resulted in a relatively higher LSR across various stages of crop growth (Table 3). Overall, the application of nitrogen positively influenced leaf area and chlorophyll content, contributing to enhanced photosynthetic activity and ultimately promoting the overall growth of the crop. These conclusions align with the findings of Sharma *et al.* (2016). At 30 and 60 DAS, the highest LSR (1.97, 188) was observed with J 1006, which was significantly superior over NK 7550 and statistically at par with NK 7328, NK 7660 and Shaktiman-5, however, the lowest LSR was observed with NK 7550. At 90 DAS, higher LSR was found in J 1006, which was notably superior over all the varieties, whereas, the lowest LSR was recorded with NK 7550. This could be attributed to the phenotypic traits of variety J 1006, which include larger leaves and narrow stems compared to other varieties (Godara *et al.* 2016).

Biomass accumulation was the most important primary factor that contributed to the green fodder yield (GFY) and dry fodder yield (DFY). The application of nitrogen at a rate of 210 kg/ha demonstrated the highest GFY (85 t/ha) and DFY (20.7 t/ha), which were statistically similar to the yields produced with 180 kg/ha of nitrogen but 10.9 and 18.3%, respectively higher as compared to application of nitrogen 150 kg/ha (Table 4). The favourable response of maize to nitrogenous fertilizer is evident. Higher nitrogen levels contributed to increased plant height and greater dry matter accumulation per plant, directly influencing the green fodder yield. Furthermore, Khan *et al.* (2014) observed a significant increase in fodder yield with rising

Table 3. Effect of different N levels and varieties on total dry matter accumulation/plant and leaf- stem ratio of maize.

Treatment	Total dry matter accumulation/plant (g)				Leaf- stem ratio (LSR)			
	30 DAS	60 DAS	90 DAS	Harvest	30 DAS	60 DAS	90 DAS	Harvest
N levels (kg/ha)								
150	4.8	23.7	76.2	137.6	1.64	1.57	0.76	0.42
180	4.9	24.2	85.7	163.8	1.74	1.64	0.84	0.57
210	5.1	26.3	93.6	167.8	2.01	1.83	0.96	0.63
SEm±	0	0.5	2	1.6	0.03	0.02	0.04	0.03
CD (p=0.05)	0.1	2.1	8	6.2	0.14	0.08	0.15	0.12
Varieties								
NK 7550	5	24.3	83.7	149.5	1.62	1.53	0.72	0.54
NK 7328	4.8	25.6	93.9	141.5	1.79	1.62	0.76	0.58
NK 7660	4.8	24.2	81.9	159.1	1.81	1.7	0.87	0.5
J 1006	5.1	23	90.9	170.5	1.97	1.88	1.07	0.63
Shaktiman-5	4.9	26.6	75.4	161.4	1.78	1.69	0.84	0.46
SEm±	0.1	0.4	3.9	6.3	0.07	0.05	0.03	0.02
CD ($p\leq$0.05)	0.2	1.3	11.4	18.4	0.21	0.31	0.1	0.07
Interaction	NS	S	S	NS	NS	NS	NS	NS

NS: Non-significant, S: Significant.

Table 4. Effect of different N levels and varieties on green and dry fodder yield of maize.

Treatment	Green fodder yield (t/ha)	Dry fodder yield (t/ha)
N levels (kg/ha)		
150	75.7	16.9
180	82.1	20.2
210	85	20.7
SEm±	1.3	0.2
CD (p=0.05)	4.9	0.8
Varieties		
NK 7550	77.8	18.4
NK 7328	73.4	17.4
NK 7660	79.8	19.6
J 1006	89.8	21.1
Shatiman-5	83.9	19.9
SEm±	3.6	0.8
CD (p=0.05)	10.5	2.3
Interaction	NS	NS

NS: Non-significant.

nitrogen levels. Comparable results were reported by various researchers for crops (Kumari *et al.* 2014). Variety J 1006 exhibited 13.4 and 18.3% higher GFY and 12.8 and 17.5% higher DFY as compared to NK 7550 and NK 7328, respectively, while being statistically comparable with NK 7660 and Shaktiman-5. Conversely, the lowest fodder yield was observed in the case of NK 7328. This outcome can be attributed to the improved plant growth, elevated plant height and increased accumulation of dry matter, all of which collectively contribute to the generation of abundant herbage. Similar findings were also highlighted by Adam *et al.* (2024), who documented substantial variations in green fodder yield and hay yields among different cultivars.

Out of all the varieties used in this experiment, fodder variety J 1006 displayed the highest plant height and the highest accumulation of above-ground dry matter throughout the growing period. Additionally, it yielded the greatest amount of green fodder (89.8 t/ha) and dry fodder (21.1 t/ha). This outcome was notably similar to NK 7660 and Shaktiman-5. The utilization of 210 kg N/ha resulted in the most substantial green fodder (85.0 t/ha) and dry fodder (20.7 t/ha) production, which was statistically equivalent to the application of 180 kg N/ha. Hence looking at overall set of morphological and yield parameters, it can be concluded that application of 210 kg N/ha with J 1006 or NK 7660 or Shaktiman-5 was found to be most effective to improve growth and overall fodder yield.

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