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PERFORMANCE OF DIFFERENT VARIETIES UNDER VARIOUS NITROGEN LEVELS IN TERMS OF YIELD AND QUALITY OF FODDER MAIZE

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SUMMARY

A field trial was carried out at the forage maize research plot of TCA, Dholi Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar, during the *Rabi* season of 2022-23 to study the performance of different varieties under various nitrogen levels in terms of yield and quality of fodder maize. The experiment was laid out in a split plot design with fifteen treatments in three replications. The treatments included three nitrogen levels (150, 180 and 210 kg ha^{-1}) in main-plots and five varieties of maize (NK-7550, NK-7328, NK-7660, J-1006 and Shaktiman-5) in sub-plots. The observations from the experiment revealed that application of 210 kg N ha^{-1} resulted in the highest green fodder yield (85.0 t/ha), dry fodder yield (20.7 t/ha), which were comparable to those obtained with 180 kg N ha^{-1}. J-1006 surpassed other varieties, producing the highest green fodder yield (89.8 t/ha) and dry fodder yield (21.1 t/ha). The use of 210 kg N ha^{-1} led to increased levels of nitrogen (N), phosphorus (P) and potassium (K) contents and their uptake. Furthermore, the crude protein content (8.61%) and crude protein yield (1.79 t/ha) were also at their peak when 210 kg N ha^{-1} was applied, showing a significant improvement over the application of 150 and 180 kg N ha^{-1}. J-1006 showed higher nitrogen content (1.35%), crude protein content (8.46%) and crude protein yield (1.80 t/ha), which was comparable with NK-7660 and Shaktiman-5. Therefore, J-1006 variety with application of 210 kg N ha^{-1} can be applied for getting maximum green fodder, dry matter and crude protein yield of *Rabi* forage maize.

Key words: Varieties, nitrogen levels, fodder maize, yield, quality

Agriculture in India is based mostly on raising and producing livestock and it has become a major source of livelihood, especially for small and marginal farmers of our country and also a source of employment for more than 70% population in rural areas. Livestock plays a crucial role in agriculture, which accounts for a large portion of our Indian economy. In India, mixed farming is the main focus and raising livestock is a significant aspect of rural life (Samal *et al.,* 2023). Animals are valued for more than their capacity to produce for human needs and other necessities. They are also the source of drought power for various agricultural activities. The demand for fodder rises throughout the busiest times of the year because of the expanding animal population. 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). The production and productivity of fodder must be enhanced to satisfy the demands of the expanding cattle population. However, the expanding cultivated area under cereal and cash crops to feed the huge population has declined the area under fodder cultivation (Nanda and Nilanjaya, 2022). Forage resource development is a more challenging problem to address than food and commercial crop growth (Kalita *et al.,* 2023). Maize has high yield potential among cereals that's why it is often referred to as the "Queen of Cereals" (Ali *et al.,* 2017). On the world level, it is grown on 193 million ha area and produces 1,123 million tonnes, which accounts for 36% of global food grain production. China has the highest area (42.13 million ha) followed by U.S.A. (39.00 million ha). Both of these countries contain 39% of the world's maize area. USA is leading in the production of maize (34%) followed by China (22%) (DES 2020a).

It is India's third-most significant cereal crop just after rice and wheat. It constitutes 9.89 million ha of total cultivated area and produces 31.65 million tonnes with a productivity of 3.19 tonnes ha^{-1} (DES 2020a). Maize is the only non-legume crop that produces both a significant amount of biomass and better nutritional quality. In comparison to other cereal forage crops, maize has a high energy content and a sizable amount of protein, making it the most ideal feed (Ipperisiel *et al.* 1989). Therefore, there is a need for high biomass-producing maize varieties and their production strategies to fulfil the ever-increasing demand for fodder purposes.

Although there are many factors that affect a crop's vegetative growth, the variety's potential, the nutrient supply system, the soil's inherent capacity to feed nutrients to the crop and the capacity of the crop plants to absorb and use the nutrients within a certain time frame are all important. A vital component that improves the quantity and quality of green biomass is nitrogen (Sarkar *et al.* 2022). Also, in order to maximise productivity, it should be associated with plant height, the number of leaves affected by various nitrogen application doses and the yield of fodder in terms of both dry matter and green forage. Nitrogen plays a major role in vegetative growth as well as grain production. Nitrogen fertilization not only increases the quality of maize, particularly its crude protein content but also influences the fodder yield (Bhoya 2014). Yet, insufficient availability of plant nutrients has a significant negative impact on yield and quality parameters. Increases in plant height, stem thickness, leaf area, leaf area index, dry matter accumulation, and yield per hectare have been associated with increased nitrogen levels (Cheema *et al.* 2010). Similar to this, the fodder maize cultivar Akbar generated maximum stem diameter, leaf area index, green fodder production and total dry matter after receiving high nitrogen through fertigation (Hassan *et al.* 2010). Considering the aforementioned facts, a research experiment was performed to evaluate the performance of different varieties under different nitrogen levels in terms of yield and quality of fodder maize.

MATERIALS AND METHODS

The research study was conducted at the forage maize research field of TCA, Dholi, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar, during the *Rabi* season of 2022-23. The experimental site is positioned at a latitude of 25º98' N and longitude of 85º60' E and it is on the southern side of the *Burhi Gandak* river, 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 present 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^{-1}) 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 cm × 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 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,

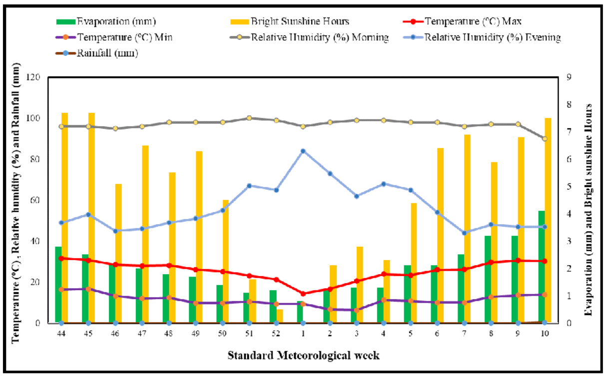

Fig. 1. Standard meteorological week wise meteorological data during the experimental period.

the critical difference (CD) was calculated at a significance level of 5%.

RESULTS AND DISCUSSION

Effect on dry matter accumulation (DMA) per plant

The accumulation of total above-ground dry matter is a crucial factor that significantly influences a crop's physiological efficiency, growth and developmental processes. The presence of DMA is crucial for achieving higher dry fodder yields as it indicates the crop's photosynthetic capacity and other synthesis processes during development. DMA levels are initially lower during early growth stages but peak at harvest. Graphical representation pertaining DMA/ plant (Fig. 2) demonstrates notable variations due to the influence of different nitrogen levels. Throughout the various stages of crop growth, we observed significant differences in the accumulation of dry matter due to different nitrogen doses. Notably, applying 210 kg ha^{-1} of nitrogen led to significantly higher dry matter accumulation compared to other nitrogen doses at 30, 60, 90 days after sowing (DAS) and during harvest. While it was statistically similar to using 180 kg ha^{-1}, it consistently remained notably higher than the 150 kg ha^{-1} dose. Conversely, the lowest dry matter accumulation was consistently observed with the application of 150 kg ha^{-1} of nitrogen across all growth stages. This trend suggests that as the nitrogen dose increased, there was a corresponding increase in dry matter accumulation. This increase can be attributed to factors such as number of leaves on the plants, greater plant height and improved photosynthesis. All of these factors together contribute to the overall increase in dry matter. These findings are consistent with previous research conducted by Ayub *et al.* (2002), Siam *et al.* (2008), Sharifi and Taghizadeh (2009), and Hassan *et al.* (2010).

Distinct varieties exhibited notable variation in DMA across all stages of crop growth. Specifically, at 30 DAS, the J-1006 variety showed the highest accumulation of dry matter, significantly surpassing NK-7328 and NK-7660, while remaining statistically similar to NK-7550 and Shaktiman-5. Moving to 60 DAS, Shaktiman-5 displayed considerably higher DMA compared to all other varieties, except for NK-7328, which exhibited statistically similar performance to Shaktiman-5. At this stage, NK-7328 showcased the highest DMA, significantly exceeding NK-7660 and Shaktiman-5, and sharing statistical similarity with NK-7550 and J-1006. When looking at the data at harvest, the J-1006 variety exhibited the maximum DMA, significantly outperforming NK-7550 and NK-7328, while remaining notably similar to NK-7660 and Shaktiman-5. However, it's important to note that variations in total above-ground DMA 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 DMA across different genotypes and growth stages. The increase in DMA/ plant with variety J-1006 over NK 7328 was 6.3% at 30 DAS and 20.5% at 30 DAS and at harvest. However, at 60 and 90 DAS, J-1006 had 10.1% and 3.2% lower DMA compared to NK 7328.

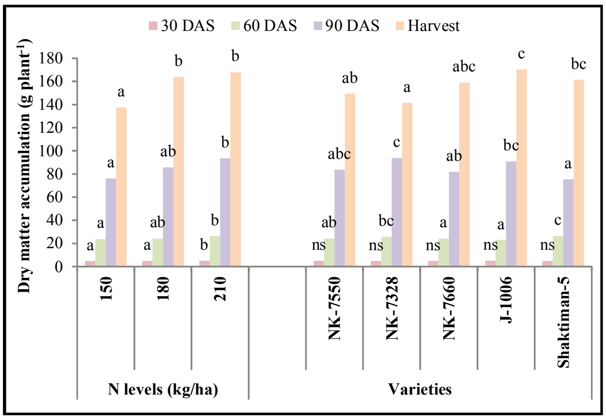

Fig. 2. Effect of N levels and varieties on total above-ground dry matter accumulation/plant at different growth stages of maize. Bars with atleast a common letters under N levels and Varieties are not significantly different as per LSD test (p=0.05).

Yield

The primary factor influencing the yield of both green and dry fodder (GFY and DFY) was biomass accumulation. Different N levels and varieties caused a notable variation in the fodder yield of varieties (Fig. 3). When it comes to nitrogen application, using 210 kg ha^{-1} demonstrated the highest GFY and DFY, and this was statistically similar to yields produced with 180 kg ha^{-1} of nitrogen. Notably, the use of 180 kg ha^{-1} of nitrogen resulted in a significant increase in both GFY and DFY compared to the application of 150 kg ha^{-1} of nitrogen. These findings are consistent with what Siam *et al.* (2008) and Hassan *et al.* (2010) have observed. On the other hand, the lowest GFY and DFY were observed when using 150 kg ha^{-1} of nitrogen. The GFY and DFY of maize showed a proportional increase as nitrogen levels were raised to 210 kg N ha^{-1}, indicating a positive response to nitrogenous fertilizer. Higher nitrogen levels contributed to increased plant height and greater dry matter accumulation per plant, directly influencing green fodder yield. This improvement in yield can be attributed to better growth parameters and increased availability of metabolites (Maqsood *et al.*2013). The notable increase in green fodder yield with higher nitrogen doses ultimately led to achieving maximum fodder yield due to improvements in various growth attributes. These trends align with findings reported by Nanda and Nilanjaya (2022), Sarkar *et al.* (2022), Khan *et al.* (2014), Shahin *et al.* (2013), and Kumari *et al.* (2014) for various crops.

Among the varieties studied, J-1006 exhibited the highest green fodder yield (GFY) and dry fodder yield (DFY), significantly surpassing NK-7550 and NK-7328 while being statistically similar to NK-7660 and Shaktiman-5. In contrast, NK-7328 had the lowest GFY and DFY. This outcome can be attributed to improved plant growth, increased plant height, and higher dry matter accumulation, all of which collectively contribute to abundant herbage production. These variations can be attributed to the inherent genetic potential of different cultivars. Similar variations in green fodder yield and dry fodder yields among different cultivars were also highlighted by Awan *et al.* (2001), consistent with the findings of Ahmad *et al.* (2012).

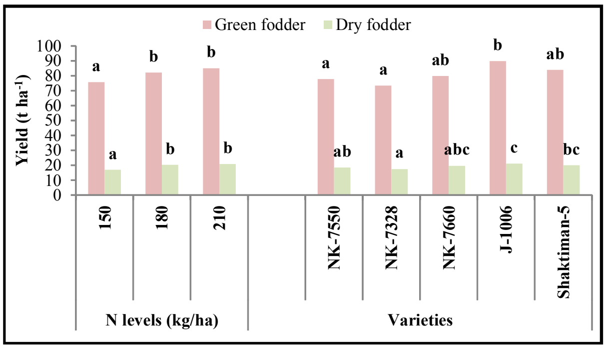

Fig. 3. Effect of N levels and varieties on green and dry fodder yield (t/ha) of maize. Bars with atleast a common letters under N levels and Varieties are not significantly different as per LSD test (p=0.05).

N, P and K content Top of Form

Different N levels caused a marked variation in N, P and K contents (Table 1). The use of nitrogen at a rate of 210 kg ha^{-1} resulted in the highest content of nitrogen (N), phosphorus (P) and potassium (K), while the application of 150 kg ha^{-1} of nitrogen yielded the lowest N, P and K content. This discrepancy can be attributed to the insufficient development of maize plants under conditions of lower fertility levels. In contrast, higher levels of nitrogen facilitated more robust plant growth, subsequently enhancing the crop's ability to absorb nutrients from the soil. These findings are consistent with the research outcomes presented by Buriro *et al.* (2014) and Meena *et al.* (2019), both of which revealed that the uptake of nitrogen, phosphorus, and potassium exhibited an increase corresponding to higher nitrogen application rates.

Different maize varieties in relation to N, P and K content differed significantly. Variety J-1006 resulted in higher N, P and K content, which was significantly higher than other varieties and was at par with the NK-7660 and Shaktiman-5 in case of N content, NK 7660 in case of P content and Shaktiman-5 in case of K content. NK-7550 resulted in the lowest N, P, K content. This could be due to the direct relationship between chlorophyll content and nitrogen content in plant tissues, indicating a linear correlation between the two and the variation in relative chlorophyll content was notable, with J-1006 recording the highest and NK-7328 having the lowest chlorophyll content. As a result, the NPK content was also found to be the highest in J-1006 and the lowest in NK-7328. Hassan *et al.* (2010) also revealed significant variations in nutrient content among different varieties.

The interaction impact of N levels and varieties in relation to P and K content were observed to be non-significant, whereas, N content was observed to be significant (Table 2 and Fig. 4). Maximum N content (1.46 %) was found in case of J-1006 along with 210 kg N ha^{-1}. This was notably superior over other treatment combinations except NK-7550 at the same N level of 210 kg N ha^{-1}. The lowest N content (1.20 %) was found in J-1006 and NK-7328 with 150 kg N ha^{-1}.

Crude protein content and crude protein yield

Crude protein is an important measure of nutritional quality, especially in the context of animal feed and agricultural products. The crude protein content and yield exhibited significant variations across different nitrogen doses (Table 1). The application of nitrogen at a rate of 210 kg ha^{-1} yielded the highest values for both crude protein content (CPC) and crude protein yield (CPY) in comparison to the rates of 180 and 150 kg ha^{-1}. Conversely, the lowest CPC and CPY were observed with the application of 150 kg N ha^{-1}. The increase in crude protein yield (CPY) was particularly notable with the use of 180 kg ha^{-1} of nitrogen, and it further improved with the application

TABLE 1

Effect of different nitrogen levels and varieties on NPK content, crude protein content and yield.

Treatment	N content (%)	P content (%)	K content (%)	Crude protein content (%)	Crude protein yield (t/ha)
N levels (kg/ha)					
150	1.26	0.19	0.54	7.78	1.34
180	1.33	0.19	0.57	8.31	1.67
210	1.38	0.2	0.61	8.83	1.79
C. D. (P=0.05)	0.04	0.01	0.02	0.22	0.06
Varieties					
NK-7550	1.3	0.18	0.51	8.35	1.49
NK-7328	1.28	0.19	0.56	8.02	1.41
NK-7660	1.33	0.2	0.57	8.29	1.64
J 1006	1.35	0.21	0.61	8.46	1.80
Shaktiman-5	1.34	0.19	0.6	8.40	1.67
C. D. (P=0.05)	0.03	0.02	0.04	0.19	0.2
Interaction (N×V)	S	NS	NS	S	NS

NS- Non-Significant, S- Significant.

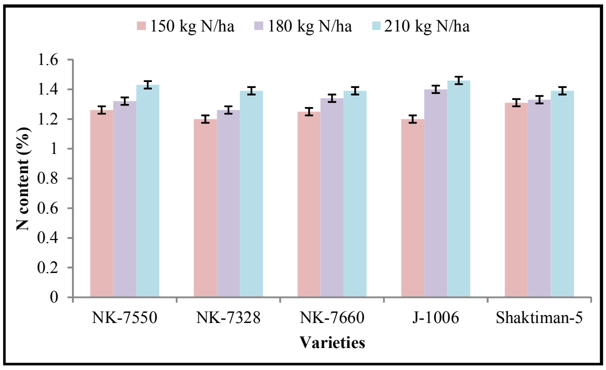

Fig. 4. Interaction effects of N levels and varieties in relation to N content. Error bars indicates LSD (p=0.05) values.

of 210 kg ha^{-1}. The impact of nitrogen on the crude protein content of maize was found to be significant, echoing the findings of Nadeem *et al.* (2009) and Carpici *et al.* (2010). This trend was closely linked to the rise in dry fodder yield (DFY), as the increase in crude protein yield was directly proportional to the augmented DFY of the maize. This was attributable to both higher protein content and an increase in dry fodder yield. Similar observations were made by Reddy *et al.* (2010) and Aslam *et al.* (2011). The application of higher nitrogen levels corresponded with elevated CPC and CPY, in agreement with the findings of Buriro *et al.* (2014). The incorporation of nitrogen played a crucial role in enhancing the protein content of maize. Nitrogen facilitates the synthesis of amino acids and proteins in plants. The application of nitrogen at a rate of 210 kg ha^{-1}, which led to the highest crude protein content (CPC), correlated with increased nitrogen uptake- a pivotal component of amino acids and proteins. Similar results were reported by Jamil *et al.* (2015).

Variety J-1006 had the highest CPC and CPY than the other varieties. Although, it was statistically similar with NK 7660 and Shaktiman-5. However, the lowest CPC and CPY resulted in variety NK-7328. The variation in crude protein content is directly related to the nitrogen content, with the highest nitrogen content observed in J 1006 and the lowest in NK-7328. As a result, J-1006 exhibited the maximum crude protein content and yield, while NK-7328 had the lowest. The outcomes align with the findings of Awan *et al.* (2001), who also identified notable differences in crude protein content and yield among various maize varieties. Similar results were highlighted by Ahmad *et al.* (2012), confirming the significant influence of nitrogen on crude protein aspects.

Interaction impacts between N levels and varieties in relation to CPC was found significant (Fig. 5), whereas, in relation to CPY were observed non-significant. Maximum CPC (9.13%) was found in case of J-1006 along with 210 kg N ha^{-1}. This was notably

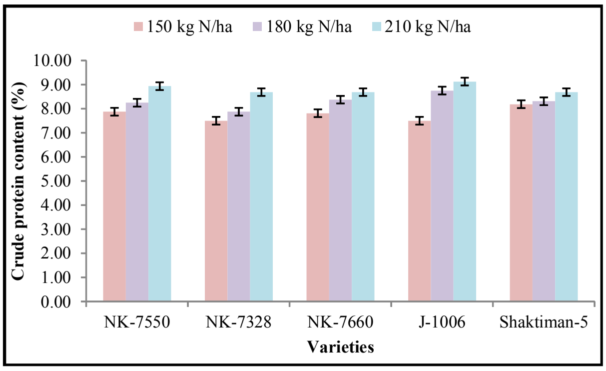

Fig. 5. Interaction effects of N levels and varieties in relation to crude protein content. Error bars indicates LSD (p=0.05) values.

superior over other treatment combinations. The lowest CPC (7.53%) was found in J-1006 and NK-7328 with 150 kg N ha^{-1}.

CONCLUSION

Based on the results, it was concluded that among the varieties, J-1006 had the highest green fodder, dry fodder and crude protein yield. Similarly, application of 210 kg N ha^{-1} resulted in the most substantial green fodder (85.0 t/ha) and dry fodder (20.7 t/ha) production, being statistically equivalent to the application of 180 kg N ha^{-1} but significantly higher crude protein yield than application of 180 kg N ha^{-1}. Therefore, J-1006 variety with application of 210 kg N ha^{-1} can be applied for getting maximum green fodder, dry matter and crude protein yield of *Rabi* forage maize.

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