Indian J. Dryland Agric. Res. & Dev. 2024 39(1): 17-19 10.5958/2231-6701.2024.00003.8

Assessment of Maize Productivity and Profitability under Varying Nitrogen Rates and Application Times in Yamuna Ravines of Uttar Pradesh

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ABSTRACT: Maize, recognized for its high genetic yield potential, plays a vital role in global agriculture due to its diverse applications. This study explores the impact of different nitrogen fertilizer rates and application timings on maize productivity and profitability in the Yamuna ravines of Uttar Pradesh. The experiment was conducted during the *kharif* season of 2022, with three N doses (75%, 100% and 125% of recommended dose of nitrogen) and three application timings (two, three and four split doses). The results revealed that both cob and grain yield as well as net returns and B:C ratio increased with higher nitrogen rates, with the highest yield recorded at 125% RDN (187.5 kg/ha), though 100% RDN showed statistically similar outcomes. Among the timings of application, three-split doses (1/3 basal+1/3 at 25-35 DAS+ 1/3 at 45-55 DAS) produced the highest cob yield, grain yield, net returns and B:C ratio, however, it was at par with 2 split doses (½ basal + ½ at 25-35 DAS). The study highlights that optimizing nitrogen rates and application timings is crucial for improving maize productivity and profitability, with three-split applications proving to be the most efficient.

Keywords: Benefit-cost ratio, cob yield, net returns, rate of N, shelling percentage

Introduction

Maize, often referred as the 'queen of cereals' is recognized for its exceptional genetic yield potential, surpassing all other cereal crops. It plays a vital role globally due to its diverse applications in food, livestock feed, fodder and as a key raw material for various industries. Maize's adaptability allows it to flourish in a wide range of climates, from tropical to temperate zones, and at elevations up to 3000 meters, making it a staple in over 166 countries (ANGRAU, 2022). In 2023-24, India's maize production was estimated at 35.67 million tonnes, yet the country faces challenges in yield efficiency, with an average yield of 330-380 kg per hectare, roughly half the global average (Choudhary and Dass, 2024). This highlights the need for improving yield efficiency to meet the increasing demand, which can be achieved through cost-effective and sustainable practices.

One critical aspect of maximizing maize yield lies in optimizing nitrogen fertilizer management. Many farmers apply N fertilizer only once or twice during the growing season, often without considering moisture conditions or the crop's nutrient demand at different growth stages (Haile *et al.,* 2012; Tadesse *et al.,* 2013). This lack of synchrony between fertilizer application and crop needs can lead to inefficient nitrogen uptake, resulting in significant nutrient loss through leaching and volatilization (Wang *et al.,* 2015). To improve nitrogen use efficiency and minimize losses, it is crucial to adjust the rate and timing of N applications. Studies have shown that splitting the total nitrogen into several smaller applications, rather than one or two large doses, enhances uptake and reduces waste (Davies *et al.,* 2020; Venterea and Coulter, 2015). Therefore, the present study was conducted to assess the impact of varying nitrogen levels and application timings on improving the productivity and profitability of maize in the Yamuna ravines of Uttar Pradesh.

Materials and Methods

The experiment was conducted at agriculture farm, ICAR-Central Institute for Research on Goats (CIRG), Makhdoom, Mathura, Uttar Pradesh during *kharif*, 2020 to study the effect of different doses of nitrogen fertilizer and their time of application on productivity and profitability of maize. The soil of the experimental field was nearly neutral in reaction (pH 7.4) with EC of 0.29 dS/m. The soil was low in organic carbon (0.24%), available nitrogen (239 kg/ha); medium in available phosphorus (42 kg/ha) and potassium (165 kg/ha). The treatments consisted of three doses of recommended nitrogen fertilizer (RDN) i.e. 75% RDN, 100% RDN and 125% RDN and three different times of application i.e. ½ basal + ½ at 25-35 DAS, 1/3 basal + 1/3 at 25-35 DAS + 1/3 at 45-55 DAS and ¼ basal + ¼ at 25 -35 DAS + ¼ at 45-55 DAS + ¼ 65-75 DAS. The experiment was laid out in a split plot design with four replications. The plot size was 4.8 m x 6 m. Maize was sown on 20th July, 2020 by using the seed rate of 20 kg/ha. Further, the crops were sown with row to row and plant to plant spacing of 60 and 20 cm, respectively. The recommended dose of fertilizers for maize in Yamuna ravines is 150 kg N/ha, 60 kg P_2O_5/ha and 40 kg

K_2O/ha. All other agronomic practices were carried out as per standard recommendations. Harvesting of the cobs was done by picking the cobs from net plot and then converted it into t/ha. All the data were subjected to statistical analysis by adopting appropriate method of analysis of variance as described by Gomez and Gomez (1984). The replicated means were subjected to ANOVA using MS excel.

Results and Discussion

Maize yield

The cob yield, grain yield and shelling percentage of maize were significantly influenced by the fertilizer rates and application timings (Table 1). Cob and grain yield increased with higher nitrogen fertilizer rates. The highest cob yield of 6.12 t/ ha and grain yield of 4.87 t/ha were observed at 125% of the RDN, while the lowest yields were recorded with 75% RDN. However, application of 100% RDN recorded statistically on par value of cob and grain yield with the application of 125% RDN. This showed that increase in nitrogen rates boosted plant growth and yield, with significant differences observed between the fertilizer treatments. The shelling percentage followed a similar trend, ranging from 76.54% at 75% RDN to 79.89% at 125% RDN. However, while the shelling percentage increased with nitrogen rates, the difference was not statistically significant, indicating that nitrogen rate had a limited impact on this parameter. The increased cob and grain yields observed in this study with higher nitrogen (N) fertilizer rates are likely due to the improved availability of nitrogen in line with the crop's requirements. This allowed the maize plants to absorb sufficient N from the soil, enhancing photosynthesis and promoting greater biomass accumulation. These findings are consistent with those of Haile *et al.* (2012), who reported optimal grain yields following the application of 120 kg N/ha in three split doses. The timing of nitrogen application also significantly influenced maize yield. Maize fertilized in three split doses produced the highest cob yield (5.92 t/ha) and grain yield (4.67 t/ha), followed by two split doses with 5.63 t/ha for cob yield and 4.42 t/ha for grain yield. The four-split dose application resulted in lower yields, with 5.40 t/ha for cob yield and 4.14 t/ha for grain yield. However, shelling percentage was less affected by the timing of nitrogen application, with minimal variations between treatments (ranging from 76.99% to 78.99%), and no significant differences were found. Incorrect timing of fertilizer application can lead to nutrient loss, causing fertilizer wastage and potential crop damage. In contrast, applying fertilizers at the optimal time improves their agronomic efficiency, reduces nutrient losses, and minimizes environmental harm due to leaching (Mosisa *et al.,* 2022).

Table 1: Effect of rates and timing of nitrogen application on yield and shelling percentage of maize

Treatment	Cob yield (t/ha)	Grain yield (t/ ha)	Shelling (%)
Rate of fertilizer application			
75% RDN	5.20	3.97	76.54
100% RDN	5.62	4.39	78.17
125% RDN	6.12	4.87	79.89
SEm±	0.19	0.14	2.36
CD (P=0.05)	0.66	0.49	NS
Timing of application			
2 split doses	5.63	4.42	78.62
3 split doses	5.92	4.67	78.99
4 split doses	5.40	4.14	76.99
SEm±	0.14	0.13	2.24
CD (P=0.05)	0.40	0.40	NS

In this study, applying nitrogen fertilizer in three split doses-1/3 at the basal stage, 1/3 at 25-35 days after sowing (DAS), and 1/3 at 45-55 DAS resulted in significantly higher cob and grain yields. This suggests that properly timed N applications align soil nitrogen availability with crop demand, facilitating optimal nutrient uptake by the plant's roots at different growth stages. Similarly, Qingfeng *et al.* (2016) found that nitrogen uptake was more efficient when N supply matched crop demand. Du *et al.* (2019) also reported that poor synchronization between nitrogen supply and crop needs, particularly when large amounts of N are applied early in the growth cycle, can lead to excessive inorganic nitrogen in the soil long before the crop can absorb it, leading to losses through leaching and volatilization. Abebe and Feyisa (2017) further supported this by stating that fertilizers applied too early are likely to be lost through leaching, as maize does not absorb nutrients efficiently in the first 10-15 days after emergence.

Maize profitability

The net returns and benefit-cost ratio of maize were significantly influenced by the fertilizer rates and application timings (Table 2). The highest net returns of ₹. 43818/ha and B:C ratio of 2.00 were achieved at 125% of the recommended dose of nitrogen fertilizer (RDN). In contrast, the lowest net returns of ₹. 30004/ha and B:C ratio of 1.72 were recorded with 75% RDN. However, the application of 100% RDN recorded statistically at par value of net returns and B:C ratio with the application of 125% RDN. The increase in nitrogen fertilizer rates resulted in higher crop productivity, leading to better economic performance. The notable increase in net returns and the B:C ratio indicates that higher nitrogen inputs are economically advantageous

for maize cultivation. These findings align closely with those of Kaur (2013), who observed a significant rise in net returns as nitrogen levels increased up to 125 kg/ha. The timing of nitrogen application also significantly impacted net returns and the B:C ratio.The application of nitrogen in three split doses i.e. 1/3 basal + 1/3 at 25-35 DAS + 1/3 at 45-55 DAS resulted in the highest net returns (₹. 41391/ha) and B:C ratio (1.97), followed by two split doses (½ Basal + ½ at 25-35 DAS) with ₹. 36906/ha and a B:C ratio of 1.86. These results might be attributed to the fact that the three-split dose application optimizes nitrogen use efficiency, leading to higher returns and profitability.

Table 2: Effect of rates and timing of nitrogen application on economics of maize production

Treatment	Net returns (₹./ha)	B:C ratio
Rate of fertilizer application		
75% RDN	30004	1.72
100% RDN	36387	1.85
125% RDN	43818	2.00
SEm±	2542	0.06
CD (P=0.05)	8795	0.20
Timing of application		
2 split doses	36906	1.86
3 split doses	41391	1.97
4 split doses	31911	1.75
SEm±	2405	0.06
CD (P=0.05)	7147	0.17

Conclusion

The study demonstrated that both nitrogen fertilizer rates and application timings significantly influenced maize productivity and profitability. The highest cob and grain yields were achieved at 125% of the recommended nitrogen dose (187.5 kg/ha), with 100% RDN showing statistically similar results. A three-split application of nitrogen (1/3 at the basal stage, 1/3 at 25-35 DAS, and 1/3 at 45-55 DAS) yielded the highest productivity, highlighting the importance of synchronizing nitrogen availability with crop demand. Additionally, the highest net returns and B:C ratio were obtained at 125% RDN which was statistically at par with 100% RDN, while the three-split application timing further optimized economic returns.

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Received: April 2024 Accepted: June 2024