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# Effect of graded levels and split application of nitrogen in yield, yield attributes and economics of hybrid maize

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### Abstract
A field experiment was conducted at AC&RI, Madurai during *Rabi* season to study the effect of graded levels and split application of nitrogen on yield of hybrid maize and to optimize nitrogen fertilizer usage. The experiment was laid on RBD and replicated thrice. Treatments comprised of $T_1$ to $T_{10}$ with RDN (250 kg/ha), and STCR (167 kg/ha) on 3 splits and nitrogen levels 225, 200, 175 and 150 kg/ha under 3 splits and 4 splits on the variety CO MH-6. Results showed that higher grain yield (9320 kg/ha) and stover yield (11180 kg/ha), was with $T_7$, it also register highest gross return (₹139802), net return (₹ 84080) and B:C ratio (2.51). From the results, it is concluded that application of $T_7$ is the optimum dosage and timing of split application of nitrogen for Co MH-6. However in economic point of view $T_6$ has an advantage.

**Keywords:** Nitrogen - optimization, split - application, STCR, CO (MH) 6, productivity

### Introduction
Maize (*Zea mays* L.) is known as "Miracle crop" in view of its several uses. It is being grown both for seed and fodder purpose. It is also gaining importance as a commercial or industrial crop; wherein a large number of by products are being manufactured out of its grain. Nitrogen, phosphorus and potassium are the essential nutrients for the production of maize. They play a crucial role in deciding the growth and yield. Phosphorus is known to stimulate early and extensive development of root systems, which enable rapid maize growth and to mature early (Sankaran *et al.*, 2005) [23].

Maize has a high yield potential and responds greatly to potassium fertilizer. Potassium affects plant metabolism, although the amounts needed for this purpose are very small. Large amounts of potassium are also needed for regulation of different physico-chemical processes in plants including water utilization by the plants (Corazzina *et al.*, 1991) [7]. Many workers have indicated that nitrogen is deficient in Indian soils with 99 per cent of soils responding to N application.

The fact that Nitrogen is the most deficient primary nutrient in Indian soils makes it the most valuable and important nutrient that needs to be optimized. The deficiency of N is usually the most limiting factor in maize production during early growth and grain filling period (El-Douby *et al.*, 2001; Zeidan *et al.*, 2006) [10, 30]. The nitrogenous fertilizer has high performance on maize yield. Even though the cost of fertilizer is high it is inevitable that N-fertilizer usage cannot be avoided but must be optimize the usage in order to obtain a sustainable growth in both in production and farming.

Time and method of N application plays an important role in efficient utilization (Mohammad *et al.*, 1999) [14]. The time of application of nitrogen is critical and is regarded as the most important decision for high yielding hybrid maize production (Walsh, 2006) [29]. Synchronization between N supply and demand enhances N uptake rates and increase N use efficiency thereby reducing N losses (Rizwan *et al.*, 2003) [20]. The rapid developmental phase of maize starts from $V_6$ during the highest N uptake takes place. Therefore, maize responds to the belated N application Binder *et al.* (2000) [5].

Generally the N application from $V_8$ to $V_{10}$ growth stages could be the appropriate time of N supply to meets its high demand (Hassan *et al.*, 2010) [11]. Nitrogen application during late vegetative growth was considered to be ideal a application practice as a means to increase nitrogen use efficiency Schmidt *et al.* (2002) [24] and Muthukumar *et al.* (2005) [16].

At present the recommendation of nitrogen is 250 kg/ha with three splits at basal (25%), 25 DAS (50%) and 45 DAS (25%). Hence, it was observed that there is scope for extended split application of nitrogen with graded level of nitrogen application.

Generally, N uptake improved and grain yield increased with split N fertilization compared to one single application at planting under irrigation system. Also the split application at different plant growth stages leads to increase in yield attributes of maize (Sangoi *et al.*, 2007) [22].

With these in mind, this present study is constructed to determine the effects graded levels and split application of N on the yield components and economics of hybrid maize.

## Materials and method

The experiment was conducted during the *Rabi* season of 2016-2017 at the Department of farm management in Agricultural College and Research Institute, Madurai (Tamil Nadu). The experimental site is situated at 9°54' N latitude and 78°54' 'E' longitude with an altitude of 147 m above mean sea level and belongs to semiarid conditions with an average rainfall of 856 mm, the maximum and minimum temperature is about 32.9 $^0$C and 20.8 $^0$C, respectively and the relative humidity is about 81.4 per cent. The soil on the field was sandy clay loam with low organic carbon (4.4 g/kg), low available nitrogen (242.3 kg/ha), medium in phosphorus (16 kg/ha) and high in potassium (450 kg/ha) with a pH of 8.1 and with a EC of 0.17 dSm$^{-1}$.

The variety adapted for the research was hybrid maize Co MH – 6. The field was laid on a randomized block design with three replications. Seeds of maize hybrids were sown on the side of the ridges by adopting a spacing of 60 x 25 cm.

The treatments comprises of applying six levels of nitrogen with three and four respective splits at different growth stages as $T_1$: RDN (250 kg/ha) in 3 splits at basal (25%), 25 DAS (50%) and 45 DAS (25%), $T_2$: STCR (167 kg N/ha) in 3 splits at basal (25%), 25 DAS (50%) and 45 DAS (25%), $T_3$: 225 kg N/ha in 3 splits at 7 DAS (25%), 25 DAS (50%) and 45 DAS (25%), $T_4$: 200 kg N/ha in 3 splits at 7 DAS (25%), 25 DAS (50%) and DAS (25%), $T_5$: 175 kg N/ha in 3 splits at 7 DAS (25%), 25 DAS (50%) and 45 DAS (25%), $T_6$: 150 kg N/ha in 3 splits at 7 DAS (25%), 25 DAS (50%) and 45 DAS (25%), $T_7$: 225 kg N/ha in 4 equal splits at 7 DAS, 25 DAS, 45 DAS, 60 DAS, $T_8$: 200 kg N/ha in 4 equal splits at 7 DAS, 25 DAS, 45 DAS, 60 DAS, $T_9$: 175 kg N/ha in 4 equal splits at 7 DAS, 25 DAS, 45 DAS, 60 DAS $T_{10}$: 150 kg N/ha in 4 equal splits at 7 DAS, 25 DAS, 45 DAS, 60 DAS. P and K was applied with the recommended dose of 75 kg/ha (RDF) as basal. Nitrogen was applied. The entire dosage of Phosphorus and Potassium was applied basally. The N, P and K fertilizers were applied in the form of urea (46% N), single super phosphate (16% $P_2O_5$) and muriate of potash (MOP) (60% $K_2O$) respectively.

STCR recommendations for $T_2$ was derived based on the fertilizer prescription equations (FPE) described for Palaviduthi series obtained from the STCR unit of the Department of Soil Science and Analytical Chemistry, Tamil Nadu Agricultural University, Coimbatore,

$FN = 3.96\,T - 0.62\,SN - 0.69\,ON$

$FP_2O_5 = 1.56\,T - 1.93\,SP_2O_5 - 0.60\,OP$

$FK_2O = 1.66\,T - 0.27\,SK_2O - 0.49\,OK$

The field was irrigated on need basis at an interval of 8 to 10 days. 0.5 kg ai/ha of pre-emergence herbicide atrazine was applied on 3 DAS by using knapsack sprayer and followed by subsequent hand weeding when needed. For observations five random tagged plants were selected from each plot and their respective yield and yield attributes were observed.

The expenditure incurred from sowing to harvest was calculated and expressed in ₹/ha. Total income obtained from grain and stover yield were calculated for individual treatments. Cost of cultivation, gross return, net return and benefit cost ratio were calculated using the price of inputs and produce that prevailed during the crop season. Cost benefit analysis was computed for all the treatments using the following formula.

(i) Gross return(₹/ha) = Economic yield (kg/ha) x Market value of the produce(₹/kg)

(ii) Net return (₹/ha) = Gross return (₹/ha) – Cost of cultivation (₹/ha)

(iii) Benefit: $\text{Cost ratio} = \dfrac{\text{Gross return (₹/ha)}}{\text{Cost of cultivation (₹/ha)}}$

## Results

### Yield attributes

The results obtained from the study reviled that application of nitrogen at 225 kg/ha in four equal splits at 7 DAS, 25 DAS, 45 DAS and 60 DAS ($T_7$) produced significantly higher cob length (21.20 cm) and cob girth (16.17 cm) (Table 1). However, it was statistically at par with 200 kg/ha of nitrogen at four equal splits ($T_8$) at 7 DAS, 25 DAS, 45 DAS and 60 DAS.

**Table 1:** Effect of graded levels and split application of nitrogen on yield attributes of hybrid maize

| Treatments | Cob length (cm) | Cob girth (cm) | No. of grains/row | No. of grain rows/cob | No. of grains/cob |
|---|---|---|---|---|---|
| $T_1$ - 250 kg N in 3 splits (RDN) | 20.84 | 16.08 | 35.33 | 14.33 | 512.17 |
| $T_2$ - 167 kg N in 3 splits (STCR) | 19.78 | 15.58 | 33.83 | 12.75 | 447.32 |
| $T_3$ - 225 kg N in 3 splits | 20.45 | 15.78 | 34.83 | 13.67 | 497.92 |
| $T_4$ - 200 kg N in 3 splits | 20.37 | 15.75 | 34.17 | 13.50 | 483.75 |
| $T_5$ - 175 kg N in 3 splits | 19.95 | 15.67 | 34.00 | 12.83 | 455.92 |
| $T_6$ - 150 kg N in 3 splits | 19.41 | 15.42 | 33.08 | 12.42 | 402.78 |
| $T_7$ - 225 kg N in 4 splits | 21.20 | 16.17 | 36.32 | 14.83 | 535.83 |
| $T_8$ - 200 kg N in 4 splits | 21.03 | 16.13 | 36.00 | 14.67 | 525.05 |
| $T_9$ - 175 kg N in 4 splits | 20.65 | 15.92 | 35.00 | 14.00 | 505.75 |
| $T_{10}$ - 150 kg N in 4 splits | 19.70 | 15.55 | 33.50 | 12.67 | 440.15 |
| SEd | 0.20 | 0.53 | 0.53 | 0.13 | 8.9 |
| CD (P = 0.05) | 0.42 | 0.37 | 1.11 | 0.27 | 18.6 |

The highest number of grains rows per cob (14.83) (Table 1), grains per row (36.32), grins per cob (535.83) were registered with application of nitrogen at 225 kg/ha in four equal splits at 7 DAS, 25 DAS, 45 DAS and 60 DAS ($T_7$). But this treatment was comparable with application of 200 kg/ha of nitrogen in four equal splits at 7 DAS, 25 DAS, 45 DAS and 60 DAS ($T_8$) and application of 250 kg/ha of nitrogen in three splits at basal (25%). The least numbers in all was associated with application of nitrogen at 150 kg/ha in three splits at 7 DAS (25%), 25 DAS (50%) and 45 DAS (25%) ($T_6$).

The application of 225 kg/ha of nitrogen in four equal splits at 7 DAS, 25 DAS, 45 DAS and 60 DAS ($T_7$) had produced the heavier cob with a weight of 204g and as well higest test weight of 39.07 g (Table 1). Application of nitrogen at 200 kg/ha in four equal splits at 7 DAS, 25 DAS, 45 DAS and 60 DAS ($T_8$) also showed a commensurate cob weight and test weight as that of $T_7$. The smallest cob weight and test weight was associated with application of nitrogen at 150 kg/ha in three splits at 7 DAS (25%), 25 DAS (50%) and 45 DAS (25%) ($T_6$).

## Yield

The result also shows that grain yield and stover yield was highly influenced by the varied dosage of nitrogen as well as with split application of nitrogen. Significantly higher grain yield of 9320 kg/ha (Table 2) was registered with application of 225 kg/ha of nitrogen in four equal splits ($T_7$) at 7 DAS, 25 DAS, 45 DAS and 60 DAS. Application of nitrogen at 200 kg/ha in four equal splits at 7 DAS, 25 DAS, 45 DAS and 60 DAS ($T_8$) was at par with 225 kg/ha in four splits. Highest stover yield of 11180 kg/ha (Table 2) was also recorded the treatment $T_7$ but was comparable with the values of stover yield from the application nitrogen at 250 kg/ha in three splits at basal (25%), 25 DAS (50%) and 45 DAS (25%) ($T_1$). The lowest grain and stover yield (Table 2) was recorded with application of nitrogen at 150 kg/ha in three splits at 7 DAS (25%), 25 DAS (50%) and 45 (25%) ($T_6$).

**Table 2:** Effect of graded levels and split application of nitrogen on yield attributes and yield of hybrid maize

| Treatments | Cob weight (g) | Test weight (g) | Grain yield (kg/ha) | Stover yield (kg/ha) | Harvest index |
|---|---|---|---|---|---|
| $T_1$ - 250 kg N in 3 splits (RDN) | 197 | 37.96 | 9110 | 10960 | 0.49 |
| $T_2$ - 167 kg N in 3 splits (STCR) | 182 | 34.72 | 8430 | 8880 | 0.47 |
| $T_3$ - 225 kg N in 3 splits | 192 | 37.06 | 8950 | 10270 | 0.48 |
| $T_4$ - 200 kg N in 3 splits | 189 | 36.31 | 8760 | 9494 | 0.48 |
| $T_5$ - 175 kg N in 3 splits | 182 | 35.10 | 8500 | 9096 | 0.47 |
| $T_6$ - 150 kg N in 3 splits | 173 | 33.10 | 8100 | 8510 | 0.45 |
| $T_7$ - 225 kg N in 4 splits | 204 | 39.07 | 9320 | 11180 | 0.49 |
| $T_8$ - 200 kg N in 4 splits | 202 | 38.63 | 9250 | 10545 | 0.49 |
| $T_9$ - 175 kg N in 4 splits | 195 | 37.41 | 9030 | 9776 | 0.48 |
| $T_{10}$ - 150 kg N in 4 splits | 179 | 34.20 | 8410 | 8669 | 0.45 |
| SEd | 2.8 | 0.49 | 99 | 181 | |
| CD (P= 0.05) | 5.8 | 1.03 | 208 | 382 | |

The harvest index of hybrid maize was higher (0.49) in the treatment where application of 225 kg/ha of nitrogen in four equal splits at 7 DAS, 25 DAS, 45 DAS and 60 DAS (T7) was applied. This treatment was comparable with application of 200 kg/ha of nitrogen applied in four equal splits at 7 DAS, 25 DAS, 45 DAS and 60 DAS (T8) and 250 kg/ha of nitrogen applied in three splits at basal (25%), 25 DAS (50%) and 45 DAS (25%) (T1). Application of 150 kg/ha of nitrogen applied in three splits at 7 DAS (25%), 25 DAS (50%) and 45 DAS (25%) (T6) registered the lowest harvest index among the treatments tested.

## Economics

The economics computed from the study reviled that the highest cost of cultivation of ₹ 56028/ha was registered with application of 250 kg/ha of nitrogen applied in three splits at basal (25%), 25 DAS (50%) and 45 DAS (25%) ($T_1$) followed by 55722/ha of the treatment ($T_7$) where application of 225 kg N/ha in four equal splits at 7 DAS, 25 DAS, 45 DAS and 60 DAS was applied. For gross return $T_7$ with 225 kg/ha of nitrogen applied in four equal splits at 7 DAS, 25 DAS, 45 DAS and 60 DAS recorded the highest of ₹ 139802/ha. This treatment was followed by treatment wherein, application of 200 kg/ha of nitrogen was applied in four equal splits at 7 DAS, 25 DAS, 45 DAS and 60 DAS ($T_8$).

**Table 3:** Effect of graded levels and split application of nitrogen on economics of hybrid maize

| Treatments | Cost of cultivation (Rs/ha) | Gross return (Rs/ha) | Net return (Rs/ha) | B:C ratio |
|---|---|---|---|---|
| $T_1$ - 250 kg N in 3 splits (RDN) | 56028 | 136650 | 80622 | 2.44 |
| $T_2$ - 167 kg N in 3 splits (STCR) | 54470 | 126456 | 71986 | 2.32 |
| $T_3$- 225 kg N in 3 splits | 55186 | 134255 | 79069 | 2.43 |
| $T_4$- 200 kg N in 3 splits | 54874 | 131402 | 76528 | 2.39 |
| $T_5$- 175 kg N in 3 splits | 54567 | 127497 | 72930 | 2.34 |
| $T_6$- 150 kg N in 3 splits | 54260 | 121503 | 67243 | 2.24 |
| $T_7$ - 225 kg N in 4 splits | 55722 | 139802 | 84080 | 2.51 |
| $T_8$ - 200 kg N in 4 splits | 55410 | 138743 | 83334 | 2.50 |
| $T_9$ - 175 kg N in 4 splits | 55103 | 135456 | 80353 | 2.46 |
| $T_{10}$- 150 kg N in 4 splits | 54796 | 126146 | 71350 | 2.30 |

Net return was highest (84080/ha) with application of 225 kg/ha of nitrogen in four equal splits as 7 DAS, 25 DAS, 45 DAS and 60 DAS ($T_7$) followed by application of 200 kg/ha of nitrogen in four equal splits at 7 DAS, 25 DAS, 45 DAS and 60 DAS ($T_8$). Highest (2.51) benefit cost ratio was also associated with $T_7$ followed by the treatment $T_8$. The lowest cost of cultivation, gross return, net return and B:C ratio was obtained with the treatment $T_6$ (Table 3) with application of 150 kg/ha of nitrogen in three splits at 7 DAS (25%), 25 DAS (50%) and 45 DAS (25%).

## Discussion

### Yield attributes

The grain yield of hybrid maize is the manifestation of yield attributes viz., cob length, cob girth, and number of grains per cob row, number of grain rows per cob, number of grains per cob, cob weight and test weight. In the present investigation, all the yield attributes were significantly and favourably influenced by the application of graded levels and split application of nitrogen.

Nitrogen plays a vital role by participating in different metabolic activities in plant system. Being an essential element, it plays an important role in crop yield attributes. In the present study, all the yield attributing characters recorded significantly higher values with the application of higher doses of nitrogen fertilizer at the rate of 225 kg/ha with four equal splits at 7 DAS, 25 DAS, 45 DAS and 60 DAS. However, these values were comparable with 200 kg/ha with four split at 7 DAS, 25 DAS, 45 DAS and 60 DAS.

The increase in cob length and cob girth in the present study might due to increase in N rates and more number of splits extended up to the end of vegetative growth period. This might have increased the photosynthate formation and better partitioning to stems which would have a favourable impact on cob length and girth of hybrid maize. These results are in close conformity with the results obtained by Ali and Raouf (2012) [2].

The highest number of grains per ear row with higher N rates might have resulted from the greater assimilates partitioning to the seeds as a result of longer growth period and higher photosynthate availability during the grain filling period (Amanullah *et al*., 2009a) [3]. Decrease in the number of grains per cob row under lower N application might be attributed to poor development of sinks and reduced translocation of photosynthates. The high N rates delayed the appearance of phenological stages, and it might be the reason for increasing the number of grains per cob row as suggested by Dawadi and Sah (2012) [8].

High levels of nitrogen with adequate split application gave the plants proper nutrition and decrease of competition and abortion of flowers at the flowering stages. These determines the number of ovule per row, the number of grains per row increased (Aktinoye *et al*., 1997) [1]. Later Mariga *et al*. (2000) [13] and (Rokhsareh and Seyed, 2015) [21] also repeated similar results of increased grain row per cob with increased dose of N as well as with extended split application of nitrogen.

The higher number of grains per cob might be due to increased N rate and increased splits. This way of nitrogen management would have increased the reproductive growth period of maize and more so, the photo assimilates were better partitioned to the seed during the grain filling stage. This could ultimately decrease the tip fill and increased the number of grains per cob. The greater number of grains per cob with higher N rates may have resulted from greater assimilates as a result of larger leaf area and more photosynthesis during grain filling. The increase in number of grains per cob with increase in the number of splits may be due to comparatively more assimilates availability than the other treatments at the time of grain filling which and might have resulted in formation of more number of grains per cob. These results are in conformity with those of Stone *et al*. (1998) [26], Soliman *et al*. (1999) [25], Andrade *et al*. (1999) [4].

The increase in cob weight is due to better plant and cob development results from better nutrition. Better nutrition could have increased leaf chlorophyll content and thus the net assimilation rate and assimilates during grain filling and development which could have resulted in the heavier cobs. These results are in close conformity with Turgut (2000) [28].

The increase in test weight might be due to the elevated rate of N level and delayed split application of N. This improves the activity of enzyme in maize which would have increased the test weight (Purcino *et al*., 2000) [19]. Majidian *et al*. (2008) [12] stated that as nitrogen is responsible for more chlorophyll and more leaf area more assimilate results. Therefore, the grains that are formed are filled with more assimilates. These results are in conformity with the findings of El-Agrodi *et al*. (2011) [9], Bohrani and Tahmasebi (2006) [6].

**Yield**

Application of different doses of nitrogen profoundly influenced the grain yield of maize. Yield is the manifestation of yield attributing characters and largely governed by source (photosynthesis) and sink (grain) relationship as it is directly related to nitrogen. The results clearly indicated that grain yield of maize was increased progressively with the graded level of nitrogen and split application. Although the grain yield of maize was significantly higher with the application of 225 N kg/ha at four equal splits, it was comparable with next lower dose of 200 N kg/ha.

The study thus reveals that instead of increasing the dose of nitrogen, increase in split application of nitrogen increases the yield. The extended split application up to 60 DAS paved a additional source of N for enhancing the photosynthetic rate and thus could have resulted in better translocation of photosynthates during grain filling period. The results are in conformity with the earlier findings of (Namvar and Seyed, 2011) [17].

Further, in the present study basal application was delayed up to 7 DAS. Hence, it could have facilitated the crop for increased uptake of nitrogen probably due to better root system which might be reason for increased growth of the plant mainly LAI. This increased LAI was later maintained by extended split application of nitrogen. Moreover, earlier reports also stated that extended split application up to flowering would result in enhanced grain filling period (Mariga *et al*., 2000) [13]. Subedi and Ma (2005) [27] earlier reported that split application of N resulted in increase transport of photo assimilated during grain filling period.

The increased rate of N application with increased split up to reproductive stage of the crop helps increasing all the yield attributing character viz., number of grain rows per cob, number of grains per cob and test weight and thus increased the yield of hybrid maize. The present findings corroborate with the findings of (Pandey and Chaudhary, 2014) [18]. Thus it can be concluded from the present study that delayed split application is favorable to meet the N demand at later stages as it has more likelihood of being utilized for sink rather than for vegetative organs and could have helped for sink development and ultimately increased the yield parameters and yield. Mungai *et al*. (1999) [15] earlier reported such results.

**Economics**

The economic analysis of hybrid maize indicated that different doses and split applications of nitrogen substantially influenced all the economic parameters. In the present study increased split application of nitrogen for the same level of nitrogen increased the cost of cultivation marginally due to increased labour cost alone. But the increased yield due to increased split application was large enough and it increased the gross return and thus net return and B:C ratio.

In case of application of N at 250 kg/ha it recorded the highest cost of cultivation due to the increased cost of N by 25 kg as compared to application of 225 kg/ha. However, the increased split application favoured for more yield and thus increased the gross return, net return and finally the B:C ratio. Hence, in all these cases, increased cost due to increased in number of split application was marked by higher returns due to increased yield.

**Conclusion**

It can be concluded from the present study that application of 225 kg N/ha of nitrogen in four equal splits at 7 DAS, 25 DAS, 45 DAS and 60 DAS ($T_7$) was found to be effective in terms of improving the yield parameters and yield. The economics obtained was also in favour for this treatment. The next best treatment was application 200 kg N/ha in four equal split at 7 DAS, 25 DAS, 45 DAS and 60 DAS ($T_8$). Hence 225 kg N/ha in four equal splits was found to be the optimum dose of nitrogen fertilizer for higher yield for and economic benefits 200 kg N/ha in four equal splits at 7 DAS, 25 DAS, 45 DAS and 60 DAS ($T_8$) can be recommended for hybrid maize. Further the study also clearly reveals that increasing the number of splits from three to four splits produce significantly more yield and benefit cost ratio.

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