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## Response of enhanced dose and differential time of nitrogen application on growth and physiological parameters of irrigated hybrid maize (*Zea mays* L.)

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### Abstract

A field experimental study was conducted during *rabi* season (2016-17) at Research farm of Tamil Nadu Agricultural University, Coimbatore to study the effect of enhanced dose and differential time of nitrogen application on the performance of irrigated hybrid maize (*Zea mays* L.). The experiment was laid out in a Factorial Randomised Block Design with three replications. The treatments comprised of two factors, in factor A, nitrogen at two levels *viz.*, N<sub>1</sub> - Recommended dose (250 kg/ha), N<sub>2</sub> - Enhanced (125% of RD) dose (313 kg/ha) and factor B consists of differential time of nitrogen application *viz.*, T<sub>1</sub> - application of nitrogen in three uneven splits (25% as basal, 50% on 30 DAS and 25% on 45 DAS), T<sub>2</sub> - application of nitrogen in four even splits (25% each at basal, 15 DAS, 30 DAS and 45 DAS), T<sub>3</sub> - application of nitrogen in four uneven splits (20% as basal, 30% on 30 DAS, 30% on 45 DAS and 20% on 60 DAS), T<sub>4</sub> - application of nitrogen in five even splits (20% each at basal, 15 DAS, 30 DAS, 45 DAS and 60 DAS) and T<sub>5</sub> - application of nitrogen in five uneven splits (10% as basal, 20% on 15 DAS, 30% on 30 DAS, 30% on 45 DAS and 10% on 60 DAS).

The growth characters *viz.*, plant height, dry matter production, leaf area index and CGR were significantly influenced by application of nitrogen at enhanced dose (125% RD) when compared to the recommended dose (100% RD). Enhanced N dose (125% RD) also showed a significant increase in yield attributes *viz.*, cob length, cob weight, number of grains per cob hundred grain weight, shelling percentage, grain yield and stover yield of maize over the recommended dose. Among the differential time of nitrogen application, nitrogen in five even splits was comparable with application of N in five uneven splits in producing higher grain and stover yield of hybrid maize.

**Keywords:** Enhanced dose, recommended dose, differential time, split

### Introduction

Maize (*Zea mays* L.) known as “Queen of Cereals” is having the highest genetic yield potential among the cereals. It is a versatile crop that can be grown over a wide range of agro climatic zones due to its C<sub>4</sub> nature. Maize is a staple food for human being and quality feed for animals, besides serves as a basic raw material to thousands of industrial products. It registered the highest growth rate among all food grains and in India, maize constitutes around 9% of the total cereals production and ranks third most important food grain after rice (42%) and wheat (38%). India is currently among top five exporters of maize in the world. However, maize is an exhaustive crop which requires macro as well as micro nutrients for attaining maximum growth and yield.

Among different essential nutrients, nitrogen is highly limiting in Indian soils that exerts a profound effect on plant growth. Nitrogen is the most critical element and it plays a key role in many physiological as well as metabolic functions (Balasubramanian and Palaniappan, 2001)<sup>[3]</sup>. It is an essential constituent of protein and nucleic acids. Moreover, it influences cell size, leaf area, and photosynthetic activity (Lawrence *et al.*, 2008)<sup>[10]</sup>. Maize requires only a fraction of nitrogen during the seedling stage, but its need is rapid once it reaches the knee-high stage and by about two weeks, reaches tasseling under favourable conditions. Plant needs for nitrogen will not end at the tasseling stage and about one-third of nitrogen requirement still have to be met during the reproductive period. Uptake of nitrogen initiates during the middle of vegetative growth period with maximum rate of nitrogen uptake occurring near silking stage

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(Hanway, 1962)<sup>[9]</sup>. Crop phenology is one of the most important aspects of crop yield determination (Carcova and Oteguai, 2001)<sup>[4]</sup>. Therefore, it is essential for predicting growth and physiological responses under varying field conditions. Gungula *et al.* (2007)<sup>[7]</sup> noted that there will be more synchrony in flowering with application of higher N. Synchronized application of nitrogen helps the plant to utilize nutrients at the time of its need. The beneficial effects of nitrogen on maize crop production are well documented. The potentiality of maize crop for its growth and development can be fully exploited by adopting suitable agronomic practices and efficient nutrient management is one such important strategy to enhance its productivity.

### Materials and Methods

The effects of enhanced dose and time of nitrogen application on the response of irrigated hybrid maize (*Zea mays L.*) was investigated at the agronomic research farm of TNAU during *rabi* season. The study area is geographically situated in Western Agro- Climatic Zone of Tamil Nadu with the coordinates of 11° N latitude, 77° E longitude and an altitude of 426.7 m above mean sea level. The soil type of experimental site is clay loam in texture, slightly alkaline pH (8.34) with low soluble salts (EC 1.34) and with low in available nitrogen (198 kg/ha), medium in available phosphorus (19.5 kg/ha) and high in available potassium (648 kg/ha). During the cropping period (Sept 2016 – Jan 2017), a total rainfall of 139.7 mm and a mean solar radiation 352.2cal/cm<sup>2</sup>/day were received. The mean maximum and minimum temperatures were 31.8°C and 21.5°C, respectively. TNAU maize hybrid CO 6 was used for the experimental study. The recommended cultural practices were carried out. The experimental trial was laid out in Factorial Randomized Block Design with three replications. The treatments comprised of two factors, in factor A, nitrogen at two levels *viz.*, N<sub>1</sub> - Recommended dose (250 kg/ha), N<sub>2</sub> - Enhanced (125% of RD) dose (313 kg/ha) and factor B consists of different time of nitrogen application *viz.*, T<sub>1</sub> - application of

nitrogen in three uneven splits (25% as basal, 50% on 30 DAS and 25% on 45 DAS), T<sub>2</sub> - application of nitrogen in four even splits (25% each at basal, 15 DAS, 30 DAS and 45 DAS), T<sub>3</sub> - application of nitrogen in four uneven splits (20% as basal, 30% on 30 DAS, 30% on 45 DAS and 20% on 60 DAS), T<sub>4</sub> - application of nitrogen in five even splits (20% each at basal, 15 DAS, 30 DAS, 45 DAS and 60 DAS) and T<sub>5</sub> - application of nitrogen in five uneven splits (10% as basal, 20% on 15 DAS, 30% on 30 DAS, 30% on 45 DAS and 10% on 60 DAS). The observations on growth parameters like plant height, dry matter accumulation, leaf area index, CGR, yield and yield attributes *viz.*, grain and stover yield, cob length, cob weight, No.of grains per cob, hundred grain weight and also recorded.

### Result and Discussion

The effect of N dose and time of application had a significant influence over the growth parameters. Plant height is a direct index to assess the growth and vigour of the plant. In general, maximum plant height was recorded with application of enhanced N dose (125% N) when compared to the recommended N dose (100% N) (Table.1.). When the N dose was enhanced from 100% RDN to 125% RDN, plant height increased by 4.2% at harvest stage. The increase in plant height with respect to increased N application indicate maximum vegetative growth of the plants under higher N availability. These results are in conformity with the results obtained by Akbar *et al.* (1999)<sup>[1]</sup> who found that plant height in maize increased with increase in N rate. Application of N in four even splits (25% each at basal, 15, 30 and 45 DAS) produced taller plants as compared to other split applications. The possible reasons might be due to steady supply of the nutrient to plants particularly during the vegetative phase and more accumulation in plant. This might have resulted in more synthesis of nucleic acids, amino acids, amide substances in meristematic tissues that ultimately enhanced multiplication of cell division and thereby increased the plant height. Similar findings were reported by Palled and Shenoy (2006)<sup>[13]</sup>.

**Table 1:** Effect of enhanced dose and time of nitrogen application on plant height (cm) at different growth stages of hybrid maize

Treatments	15 DAS			30 DAS			45 DAS			60 DAS			Harvest		
	N <sub>1</sub>	N <sub>2</sub>	Mean	N <sub>1</sub>	N <sub>2</sub>	Mean	N <sub>1</sub>	N <sub>2</sub>	Mean	N <sub>1</sub>	N <sub>2</sub>	Mean	N <sub>1</sub>	N <sub>2</sub>	Mean
T <sub>1</sub>	29.5	29.8	29.7	81.5	85.3	83.4	171.3	181.0	176.2	223.0	235.3	229.2	230.3	240.0	235.2
T <sub>2</sub>	29.4	29.7	29.6	90.9	95.1	93.0	182.3	190.0	186.2	247.3	256.0	251.7	255.0	262.0	258.5
T <sub>3</sub>	28.8	28.9	28.9	79.1	82.4	80.8	159.7	170.6	165.2	233.6	245.3	239.5	237.0	249.3	243.2
T <sub>4</sub>	28.7	29.2	29.0	88.9	93.6	91.3	176.0	188.0	182.0	241.0	253.3	247.2	251.0	262.6	256.8
T <sub>5</sub>	28.5	28.7	28.6	88.1	91.8	90.0	175.3	186.0	180.7	237.0	248.6	242.8	245.0	256.0	250.5
Mean	29.0	29.3		85.7	89.6		172.9	183.1		236.4	247.7		243.7	254.0	
	N	T	N x T	N	T	N x T	N	T	N x T	N	T	N x T	N	T	N x T
SEd	0.26	0.42	0.59	1.5	2.4	3.4	3.6	5.7	8	3.7	5.9	8.3	3.3	5.2	7.3
CD (0.05)	NS	NS	NS	3.2	5.0	NS	7.5	11.9	NS	7.8	12.4	NS	6.9	10.9	NS

**Table 2:** Effect of enhanced dose and time of nitrogen application on dry matter production (kg/ha) at different growth stages of hybrid maize

Treatments	15 DAS			30 DAS			45 DAS			60 DAS			Harvest		
	N <sub>1</sub>	N <sub>2</sub>	Mean	N <sub>1</sub>	N <sub>2</sub>	Mean	N <sub>1</sub>	N <sub>2</sub>	Mean	N <sub>1</sub>	N <sub>2</sub>	Mean	N <sub>1</sub>	N <sub>2</sub>	Mean
T <sub>1</sub>	73	77	75	1693	1794	1744	3943	4463	4203	11133	12600	11867	13433	15434	14433
T <sub>2</sub>	72	77	74	1943	2103	2023	4537	5318	4928	13267	15733	14500	15217	18299	16758
T <sub>3</sub>	71	75	73	1662	1756	1709	3831	4384	4108	10800	12533	11667	13134	15367	14250
T <sub>4</sub>	71	75	73	1927	2069	1998	4376	5101	4739	12600	15000	13800	15933	19100	17516
T <sub>5</sub>	70	74	72	1883	2037	1960	4251	4993	4622	12067	14533	13300	15233	18399	16816
Mean	71	75		1822	1952		4188	4852		11973	14080		14680	17546	
	N	T	N x T	N	T	N x T	N	T	N x T	N	T	N x T	N	T	N x T
SEd	1	2	3	33	52	73	81	129	182	233	368	521	288	455	644
CD (0.05)	3	NS	NS	69	109	NS	171	270	NS	489	774	NS	605	957	NS

The results of the experiment indicated that the maize DMP at various growth stages increased significantly with enhanced N dose (Table.2.). The increase in dry matter at enhanced dose (*i.e.*, 125% RDN) when compared to the recommended N dose (100% RDN) might be due to the increased plant height, leaf area, LAI and LAD, in turn resulting in more photosynthates accumulation. Greef *et al.* (1999)<sup>[6]</sup> reported a positive correlation between N rate and dry matter yield in maize. Similarly, dry matter at various growth stages had increased significantly with increase in number of N splits.

Higher DMP was noticed in more number of splits *i.e.*, application of N in four even splits. And it was comparable with N application in five (even and uneven) splits. Application of N at later vegetative stage of the crop extended the regular availability of nutrient in soil (Amanullah *et al.*, 2009)<sup>[2]</sup> and could produce relatively more assimilates. This might be the possible cause of greater DMP of maize with increased number of N split applications. Similar findings were reported by several researchers (Rajcan and Tollenaar, 1999; Mariga *et al.*, 2000; Scharf *et al.*, 2002)<sup>[11, 15, 17]</sup>.

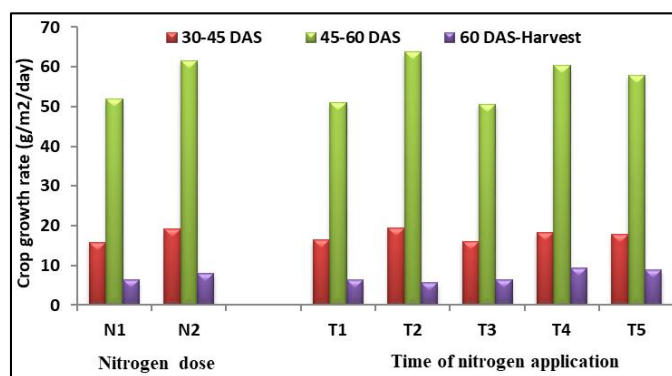
**Table 3:** Effect of enhanced dose and time of nitrogen application on leaf area index at different growth stages of hybrid maize

Treatments	15 DAS			30 DAS			45 DAS			60 DAS			Harvest		
	N <sub>1</sub>	N <sub>2</sub>	Mean	N <sub>1</sub>	N <sub>2</sub>	Mean	N <sub>1</sub>	N <sub>2</sub>	Mean	N <sub>1</sub>	N <sub>2</sub>	Mean	N <sub>1</sub>	N <sub>2</sub>	Mean
T <sub>1</sub>	0.26	0.27	0.26	1.93	1.96	1.95	3.20	3.60	3.40	4.33	4.80	4.56	2.70	3.26	2.98
T <sub>2</sub>	0.25	0.27	0.26	2.16	2.36	2.26	3.66	4.40	4.03	4.80	5.53	5.16	3.00	3.63	3.31
T <sub>3</sub>	0.25	0.27	0.26	1.90	1.96	1.93	3.13	3.53	3.33	4.40	5.20	4.80	3.10	3.73	3.41
T <sub>4</sub>	0.25	0.27	0.26	2.16	2.33	2.25	3.56	4.13	3.85	4.63	5.26	4.95	3.53	3.80	3.66
T <sub>5</sub>	0.24	0.26	0.25	2.13	2.23	2.18	3.53	4.03	3.80	4.60	5.20	4.90	3.23	3.76	3.50
Mean	0.25	0.27		2.06	2.17		3.42	3.94		4.55	5.20		3.11	3.64	
	N	T	N x T	N	T	N x T	N	T	N x T	N	T	N x T	N	T	N x T
SEd	0.004	0.007	0.01	0.033	0.053	0.076	0.066	0.105	0.149	0.088	0.139	0.197	0.061	0.096	0.137
CD (0.05)	0.009	NS	NS	0.071	0.112	NS	0.141	0.223	NS	0.185	0.294	NS	0.128	0.204	NS

The data on table 3 indicates that Leaf area index showed a steady increase up to 60 DAS and thereafter a declining trend was noticed towards harvest stage. The increase in LAI was possibly due to higher N level which increased the LAI because of increased chlorophyll content of plants influencing the cell and tissue growth with increased photosynthetic efficiency. The results are in concordance with the findings of Oscar and Tollenaar (2006)<sup>[12]</sup> Application of N in four even splits at basal, 15, 30 and 45 DAS enhanced the LAI at 30, 45 and 60 DAS, while N application in five even splits produced higher LAI at harvest. Application of N in maximum number of splits (four or five) and upto later stage of crop growth because of optimum and timely availability of N had increased the photosynthetic activity and LAI of maize. The results are in accordance with the findings of Pandey *et al.* (2015)<sup>[14]</sup>. However there was no significant interaction effect observed between the nitrogen doses and time of application on influencing the leaf area index of maize.

Increase in CGR with increased N application might be due to larger LAI, as CGR is a product of LAI and NAR as reported by Hammad *et al.* (2011)<sup>[18]</sup>. With regard to time of N application, application of N in four even splits (T<sub>2</sub>) recorded the highest CGR values of 13.0, 19.36 and 63.82 g/m<sup>2</sup>/day in 15-30 DAS, 30-45 DAS and 45-60 DAS, respectively. However, the treatment was statistically comparable with treatments T<sub>4</sub> and T<sub>5</sub> in 15-30 DAS while with the treatment T<sub>4</sub> alone in 30-45 DAS and 45-60 DAS. At 60 DAS - harvest period, application of N in five even splits (T<sub>4</sub>) registered significantly highest CGR value of 9.29 g/m<sup>2</sup>/day. The lowest CGR of 13.00, 19.36 and 63.82 g/m<sup>2</sup>/day was recorded with application of N in four uneven splits (T<sub>3</sub>) at 15-30 DAS, 30-45 DAS and 45-60 DAS, respectively, while it was treatment T<sub>2</sub> (5.65 g/m<sup>2</sup>/day) at 60 DAS - harvest period. It was observed no significant difference between the N doses and time of application in their interaction effect on CGR of maize.

Leaf area duration (LAD) was statistically highly significant with N dose and time of application. Maximum leaf area duration was observed with application of enhanced N dose (125%). This might be the fact that increased N prolongs the vegetative stage of the crop and resulted in longer LAD. In addition, higher LAI and the role of N in stay green characteristics of maize plants led to higher LAD in the experiment. With regard to time of N application, N in four even splits at basal, 15, 30 and 45 DAS registered higher LAD at time intervals of 15-30, 30-45 and 45-60 DAS, respectively. (Table.4.) At harvest, N application in five even splits recorded higher LAD and was comparable with N application in five uneven splits. The reason might be that N application in more number of splits (four or five) resulted in optimum and timely N supply to the crop even at later stage when compared to other split applications. This is in consonance with the remarks of Reddy and Reddy (2011)<sup>[16]</sup> who noted that late application of nitrogen increased leaf area and leaf area duration considerably.



**Fig 1:** Effect of enhanced dose and time of nitrogen application on crop growth rate (g/m<sup>2</sup>/day) at periodic growth intervals to till harvest stage of hybrid maize

The graphical data represented figure 1. revealed that nitrogen dose and time of application had significantly influenced the CGR of hybrid maize. Among them, application of enhanced N dose (125% RD) registered higher CGR compared to recommended N dose (N<sub>1</sub>) at the respective growth stage

**Table 4:** Effect of nitrogen dose and time of application on leaf area duration (days) at different growth stages of hybrid maize

Treatments	15-30 DAS			30-45 DAS			45-60 DAS			60 DAS-Harvest		
	N <sub>1</sub>	N <sub>2</sub>	Mean	N <sub>1</sub>	N <sub>2</sub>	Mean	N <sub>1</sub>	N <sub>2</sub>	Mean	N <sub>1</sub>	N <sub>2</sub>	Mean
T <sub>1</sub>	16.3	16.7	16.5	38.5	41.6	40.1	56.8	63.1	60.0	52.9	60.8	56.9
T <sub>2</sub>	18.4	19.9	19.2	43.8	50.6	47.2	63.2	74.4	68.8	58.3	68.9	63.6
T <sub>3</sub>	15.9	16.6	16.3	37.6	41.1	39.4	56.7	65.7	61.2	56.5	67.0	61.8
T <sub>4</sub>	18.2	19.6	18.9	42.8	48.4	45.6	61.3	70.5	65.9	61.2	68.2	64.7
T <sub>5</sub>	17.7	18.7	18.2	42.4	47.0	44.7	61.0	69.3	65.2	58.6	67.1	62.9
Mean	17.3	18.3		41.0	45.7		59.8	68.6		57.5	66.4	
	N	T	N x T	N	T	N x T	N	T	N x T	N	T	N x T
SEd	0.3	0.5	0.7	0.8	1.2	1.7	1.1	1.8	2.6	1.1	1.7	2.5
CD (0.05)	0.7	1.0	NS	1.6	2.6	NS	2.4	3.8	NS	2.3	3.6	NS

Chlorophyll is one of the most important chelates for plants, which has the capacity to channelise the energy of sunlight into chemical energy through the process of photosynthesis. In addition to indicate the plant nitrogen status, chlorophyll content is an important indicator of leaf senescence. It was observed from the experiment that enhanced N dose as well as the time of N application had a positive influence on SPAD values. In general, SPAD meter readings increased at enhanced N dose at each stage of measurement. Better

response was observed with application of higher N dose (125% RDN) with four even splits at most of the crop growth stages while it was with N application under five even splits at harvest. This might be due to the fact that distribution of more N evenly during each growth stage resulted in maintenance of higher auxin level which in turn resulted in better plant growth parameters and presumably the chlorophyll content of the leaves. The results are in accordance with the findings of EL- Agrodi *et al.* (2011) [5].

**Table 5:** Effect of nitrogen dose and time of application on SPAD values at different growth stages of hybrid maize

Treatments	15 DAS			30 DAS			45 DAS			60 DAS			Harvest		
	N <sub>1</sub>	N <sub>2</sub>	Mean	N <sub>1</sub>	N <sub>2</sub>	Mean	N <sub>1</sub>	N <sub>2</sub>	Mean	N <sub>1</sub>	N <sub>2</sub>	Mean	N <sub>1</sub>	N <sub>2</sub>	Mean
T <sub>1</sub>	36.5	39.0	37.8	37.4	38.5	38.0	38.8	40.6	39.7	39.2	41.0	40.1	37.4	39.4	38.4
T <sub>2</sub>	36.6	39.4	38.0	38.7	39.8	39.3	39.0	41.5	40.3	39.5	41.8	40.7	37.9	39.6	38.8
T <sub>3</sub>	36.0	37.4	36.7	36.9	37.6	37.3	37.6	39.5	38.6	38.2	39.8	39.0	38.5	39.7	39.1
T <sub>4</sub>	36.2	37.4	36.8	38.4	39.1	38.8	38.8	41.4	40.1	39.4	41.7	40.6	38.8	39.8	39.3
T <sub>5</sub>	35.2	36.5	35.9	38.2	38.8	38.5	38.6	41.3	40.0	39.3	41.6	40.5	38.7	39.7	39.2
Mean	36.1	37.9		37.9	38.8		38.6	40.9		39.1	41.2		38.3	39.6	
	N	T	N x T	N	T	N x T	N	T	N x T	N	T	N x T	N	T	N x T
SEd	0.21	0.32	0.46	0.15	0.24	0.34	0.39	0.62	0.88	0.41	0.65	0.91	0.41	0.64	0.91
CD(0.05)	0.43	0.68	NS	0.32	0.51	NS	0.83	NS	NS	0.85	NS	NS	0.86	NS	NS

## Conclusion

Application of enhanced dose of nitrogen @ 125% RDN (313 kg N/ha) has significantly improved the growth and yield attributes of hybrid maize CO -6 under irrigated conditions. It could be concluded that the application of enhanced nitrogen dose @ 125% RD (313 kg/ha) in five even splits (20% each on basal, 15, 30, 45 and 60 DAS) was found to maximize the productivity and profitability of TNAU maize hybrid CO 6 under irrigated conditions.

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