www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(5): 1156-1159

www.thepharmajournal.com
Received: 01-03-2021
Accepted: 06-04-2021

YB Madagoudra
Department of Agronomy,
N. M. College of Agriculture,
Navsari Agricultural University,
Navsari, Gujarat, India

RB Ardeshna
Department of Agronomy,
N. M. College of Agriculture,
Navsari Agricultural University,
Navsari, Gujarat, India

Jakkannagari Chaithanya
Department of Agronomy,
N. M. College of Agriculture,
Navsari Agricultural University,
Navsari, Gujarat, India

Lokesh R
Department of Plant Pathology,
N. M. College of Agriculture,
Navsari Agricultural University,
Navsari, Gujarat, India

Corresponding Author:
YB Madagoudra
Department of Agronomy,
N. M. College of Agriculture,
Navsari Agricultural University,
Navsari, Gujarat, India

The effect of rate and time of nitrogen application on growth, yield attributes, yield and economics of summer maize (*Zea mays* L.)

YB Madagoudra, RB Ardeshna, Jakkannagari Chaithanya and Lokesh R

DOI: https://doi.org/10.22271/tpi.2021.v10.i5o.6365

Abstract
Background: Nitrogen management in maize production system is one of the main concerns since it is the most important and primary nutrient for growth and development of the crop. Optimum rate and time of N application can enhance yield and nutrient use efficiencies. The current study was aimed to evaluate optimum rate and time of nitrogen application in summer maize (*Zea mays* L.).
Methods: A field experiment was conducted at College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari to study the "Effect of rate and time of nitrogen application on growth and yield of summer maize (*Zea mays* L.)". The treatments of the study included three rates (60, 90 and 120 kg N ha^{-1}) of nitrogen and three timings (two equal splits at sowing and 30 DAS, three equal splits at sowing, 30 and 45 DAS and four equal splits at sowing, 30, 45 and 60 DAS).
Result: The results revealed significantly higher growth and yield parameters with 120 kg N ha^{-1}. The maximum grain yield (3463 kg ha^{-1}) was obtained under 120 kg N ha^{-1}. The split application of nitrogen in four equal splits at sowing, 30, 45 and 60 DAS also had significant effect on growth and yield attributes of summer maize. Significantly highest grain yield (3331 kg ha^{-1}) was obtained under four splits. The interaction between rate and time of nitrogen application had significant effect. The treatment combination involving 120 kg N ha^{-1} with four splits at sowing, 30, 45 and 60 DAS obtained significantly higher grain weight per cob (55.48 g) and grain yield (4084 kg ha^{-1}). The treatment combination also accrued the maximum net realization (₹ 66680 ha^{-1}) and B:C ratio (2.51).

Keywords: Maize, net realization, nitrogen, rate, split application, yield attributes

Introduction
Maize (*Zea mays* L.) also known as corn belongs to family Poaceae is one of the important cereal crops of the world due to its high value as staple food as well as straw demand for animal feed. It is one of the most versatile crops having wider adaptability and grown under varied agro-climatic conditions, diverse seasons and ecologies for various purposes. Globally, maize is known as "queen of cereals" because of its highest genetic yield potential among the cereals. It is cultivated on nearly 183 m ha in the world with production of 1065 million tons with a productivity of 5820 kg ha^{-1} (Anon., 2016) [2]. It is grown in more than 160 countries having wider diversity of soil, climate, biodiversity and management practices that contributes 36 per cent to the global grain production. USA is the largest producer of maize contributing nearly 35 per cent of the total maize production in the world. Maize is considered to be the driver of the US economy. The USA has the highest productivity ($\geq$ 10.96 t ha^{-1}) which is double of the global average (5.82 t ha^{-1}).
Nitrogen plays a key role in several physiological and metabolic processes. The most important role of N in the plant is its presence in the structure of the protein and nucleic acids and is essential for enzymatic, biochemical and physiological reactions in plant metabolism (Sharma *et al.*, 2017) [11]. Therefore, adequate supply of N is necessary to achieve higher yield. The deficiency of this element has been considered as one of the major yield limiting factors for cereal production (Shah *et al.*, 2003) [9]. Application of nitrogen at low rates reduced grain yield by 43-74 per cent and number of grains per plant up to 33-65 per cent (Andrea *et al.*, 2006) [1]. Therefore, it is necessary to give optimum dose of nitrogen for improving yield of maize (Li *et al.*, 2010) [5].
The time of Nitrogen application plays a very important role in maize yield (Scharf *et al.*, 2002). The time of nitrogen application at appropriate crop growth stage when it is needed

most and taken up at high rates by plants could enhance nitrogen use efficiency by reducing the immobilization, denitrification and leaching losses (Rizwan *et al*., 2003) [8].

Rahman *et al*. (2016) [7] reported that N fertilisation at booting and silking stages caused significant increments in grain yield. Furthermore, Gehl *et al*. (2005) [3] also observed that maize N uptake improved and grain yield increased with split N fertilisation compared to single application at planting under irrigation system.

There is little information available on nitrogen requirement and its time of application for summer maize. Therefore, the present study was planned to determine the optimum dose and time of nitrogen application in summer maize.

Material and Methods

A field experiment was conducted during summer 2018 at college farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari to assess the effect of rate and time of nitrogen application on growth, yield attributes, yield and economics of maize. The soil of the experimental site was clayey in texture (62.17%), medium in organic carbon (0.56%), low in available nitrogen (192.86 kg ha^{-1}), medium in available phosphorus (49.58 kg ha^{-1}) and available potassium (501.42 kg ha^{-1}). The soil reaction was slightly alkaline (pH 8.15) with normal electrical conductivity.

In all, nine treatment combinations, consisting of three rates (60, 90 and 120 kg N ha^{-1}) and three timings (two equal splits at sowing and 30 DAS, three equal splits at sowing, 30 DAS and 45 DAS and four equal splits at sowing, 30 DAS, 45 DAS and 60 DAS) of nitrogen application were evaluated in factorial randomized block design with four replications. Before the experiment, pigeon pea was grown in the field and harvested in January and kept fallow prior to maize sowing. The maize variety GM-6 was sown on February 19, 2018. A seed rate of 25 kg ha^{-1} was used by keeping row to row distance of 60 cm and plant to plant distance of 20 cm. Sowing was done manually by maintaining plant to plant spacing with the help of marked stick (20 cm) as per the treatments. Seeds were covered with soil and irrigation was given immediately after sowing.

Bio-compost at 5 t ha^{-1} was applied on the experimental field before sowing and mixed well. Nitrogen was applied as per the treatments. Common application of 40 kg P_2O_5 ha^{-1} was made as basal. The sources of nitrogen and phosphorus were urea and single super phosphate, respectively. Total seven irrigations were given during the crop period.

Data on different growth parameters *viz.*, plant height (cm), dry matter per plant (g) and days to 50 per cent tasseling and yield attributes *viz.*, number of cobs per plant, cob length (cm), cob girth (cm), number of grains per cob, grain weight per cob and yield were collected to find out the best treatment. Ten plants from each plot were selected randomly to study these parameters. Net realization (₹ ha^{-1}) was calculated by deducting the cost of cultivation from the gross returns (₹ ha^{-1}).

Results and Discussion

The results of the present study as well as relevant discussion have been summarized under following heads:

Growth parameters

The data pertaining to growth parameters of maize *viz.*, plant height (cm), dry matter per plant (g) and days to 50 per cent tasseling are presented in Table 1. The results revealed that application of 120 kg ha^{-1} (N_3) produced taller plants as compared to the lower doses of nitrogen (N_1-60 kg ha^{-1} and N_2-90 kg ha^{-1}). Significantly higher plant height (208.13 cm) at harvest was observed under 120 kg N ha^{-1} that remained at par with 90 kg N ha^{-1}. The total plant dry matter accumulation was significantly affected by the doses of nitrogen application both at 45 DAS and at harvest. The dry matter accumulation improved with the advancement of plant towards maturity. The highest dry matter accumulation at 45 DAS (26.80 g/plant) and at harvest (170.15 g $plant^{-1}$) was recorded under 120 kg N ha^{-1} (N_3) which was at par with 90 kg N ha^{-1} (N_2). Higher levels of nitrogen showed a significant effect on days to 50 per cent tasseling. Application of 120 kg N ha^{-1} (N_3) increased the days to 50 percent tasselling (58.55 days) as compared to lower levels (N_1-60 kg ha^{-1} and N_2-90 kg ha^{-1}). Similar findings were observed by Niaz *et al*. (2014) [6], Sharma *et al*. (2017) [11] and Hammad *et al*. (2013) [4].

The split application of nitrogen also had a significant effect on almost all the growth parameters of summer maize. Application of nitrogen in four equal splits at sowing, 30 DAS, 45 DAS and 60 DAS (T3) recoded significantly higher plant height (206.92 cm) at harvest which remained at par with three equal splits at sowing, 30 DAS and 45 DAS. The time of nitrogen application also had a significant effect on the plant dry matter accumulation both at 45 DAS and at harvest. The maximum dry matter accumulation (26.52 g/plant) at 45 DAS was obtained with nitrogen application in two equal splits at sowing and 30 DAS (T_1) which was found at par with nitrogen application in three equal splits at sowing, 30 DAS and 45 DAS (T2) (24.55 g/plant). The higher dry matter accumulation against T_1 at 45 DAS was due to higher nitrogen supply at the initial growth stages which had increased the vegetative growth and accelerated cell division and cell elongation which ultimately resulted in luxuriant growth of the crop. Application of nitrogen in four equal splits at sowing, 30 DAS, 45 DAS and 60 DAS (T_3) recorded significantly higher dry matter accumulation (167.49 g) at harvest but was found at par with the treatment T_2 (159.39 g).

Days to 50 per cent tasseling significantly varied with the timings of nitrogen application. Nitrogen application in three equal splits at sowing, 30 DAS and 45 DAS (T_2) significantly increased the days to 50 per cent tasseling (58.44) which was found at par with nitrogen application in four equal splits at sowing, 30 DAS, 45 DAS and 60 DAS (T_3) (54.65). This increase in number of days to 50 per cent tasseling with nitrogen application in three equal splits (T_2) might be due to timely availability of nitrogen, which resulted in increased vegetative growth of the crop which delayed the days to 50 per cent tasseling. Similar findings were observed by Sharifi and Namvar (2016) [10] and Hammad *et al*. (2013) [4].

Yield attributes and yield

All the yield attributes except number of grain rows per cob of maize were influenced significantly by different levels of nitrogen (Table 1). The maximum number of cobs per plant (1.23), cob length (14.02 cm) and cob girth (11.89 cm) were obtained with 120 kg N ha^{-1} (N_3) which remained at par with 90 kg N ha^{-1} (N_2). The findings also showed that the maximum number of grain rows per cob (13.97) was recorded with 120 kg N ha^{-1} (N_3). Application of 120 kg N ha^{-1} (N_3) recorded significantly highest number of grains per cob (275.85), grain weight per cob (49.43 g) and 100-grain weight (18.52 g) as compared to lower levels of nitrogen (N_1-60 kg N ha^{-1} and N_2-90 kg N ha^{-1}). Nitrogen levels had significant influence on the grain and straw yield. Increasing the rate of nitrogen application significantly increased the grain yield of maize up to 120 kg N ha^{-1} (3463 kg ha^{-1}). Though 120 kg N ha^{-1} recorded significantly higher straw yield (7438 kg ha^{-1}) over 60 kg N ha^{-1}, it remained at par with 90 kg N ha^{-1}. The magnitude of increase in grain yield with 120 kg N ha^{-1} was to the turn of 23.39 and 38.46 per cent, respectively over 90 kg N ha^{-1} (N2) and 60 kg N kg N ha^{-1} (N1), while the corresponding increase in straw yield was to the turn of 7.34 and 17.48 per cent, respectively.

The split application of nitrogen in four equal splits at sowing, 30 DAS, 45 DAS and 60 DAS (T_3) produced the maximum number of cobs per plant (1.22), cob length (13.81 cm), cob girth (11.68 cm), maximum number of grains per cob (271.16) and grain weight per cob (47.48 g) which remained at par with nitrogen application in three equal splits at sowing, 30 DAS and 45 DAS (T_2). The findings also showed that the number of grain rows per cob (13.70) was highest with T_3. 100-grain weight was increased significantly up to nitrogen application in four splits. The treatment also recorded significantly the highest 100-grain weight (17.92 g) compared to other nitrogen timings T_1 (two equal splits at sowing and 30 DAS) and T_2 (three equal splits at sowing, 30 DAS and 45 DAS). The application of nitrogen in four equal splits at sowing, 30 DAS, 45 DAS and 60 DAS (T_3) recorded significantly highest grain yield (3331 kg kg N ha^{-1}), while straw yield (7171 kg N ha^{-1}) (T_3) remained at par with nitrogen application in three equal splits at sowing, 30 DAS and 45 DAS (T_2). The lowest grain (2731 kg N ha^{-1}) and straw yield (6104 kg N ha^{-1}) were recorded under nitrogen application in two equal splits at sowing and 30 DAS (T_1).

Interaction

Grain weight per cob and grain yield of maize were influenced significantly due to positive and significant interaction between rate and time of nitrogen application (Table 2). Treatment combination involving 120 kg N ha^{-1} applied in four equal splits at sowing, 30 DAS, 45 DAS and 60 DAS recorded significantly higher grain weight per cob (55.48 g) and grain yield (4084 kg ha^{-1}) as compared to the rest of the treatment combinations except that grain weight per cob was at par with 120 kg N ha^{-1} applied in three equal splits at sowing, 30 DAS and 45 DAS. The treatment combination also accrued the maximum net realization (₹ 66680 ha^{-1}) and B:C ratio (2.51).

Economics

Economic assessment (Table 3) revealed that the maximum gross and net realization of ₹ 81697 N ha^{-1} and ₹ 55533 ha^{-1}, respectively with the B:C ratio of 2.12 were obtained under 120 kg N ha^{-1} (N_3) followed by treatment 90 kg N ha^{-1} (N_2) (₹ 73118 ha^{-1} and ₹ 47319 ha^{-1} respectively) with the B:C ratio of 1.83. The lowest gross, net realization and B:C ratio (₹ 60243 ha^{-1}, ₹ 34815 ha^{-1} and 1.37 respectively) was recorded in 60 kg N ha^{-1} (N_1). The increase in net profit and B:C ratio under the nitrogen level 120 kg ha^{-1} was due to yield differences.

The study also revealed that the maximum gross and net realization of ₹ 78649 ha^{-1} and ₹ 52496 ha^{-1}, respectively with the B:C ratio of 2.01 were obtained under nitrogen application in four equal splits at sowing, 30 DAS, 45 DAS and 60 DAS (T_3) followed by nitrogen application in three equal splits at sowing, 30 DAS and 45 DAS (T_2) (₹ 71028 ha^{-1} and ₹ 45231 ha^{-1} respectively) with the B:C ratio of 1.75. The lowest gross, net realization and B:C ratio (₹ 65381 ha^{-1}, ₹ 39940 ha^{-1} and 1.57 respectively) was recorded in T_1 (two equal splits at sowing and 30 DAS). The increase in net profit and B:C ratio under T_3 was due to yield differences.

Table 1: Effect of rate and time of nitrogen application on the growth, yield attributes and yield of summer maize.

Treatments	Plant height (cm) at harvest	Total dry matter (g/plant) at harvest	Days to 50% tasseling	Cob length (cm)	Cob girth (cm)	Number of grains per cob	100-grain weight (g)	Grain weight per cob (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index
Rate of N application (N)											
N_1: 60 kg N ha^{-1}	179.62	148.82	52.31	12.28	10.31	235.29	14.43	38.65	2501	5682	30.58
N_2: 90 kg N ha^{-1}	193.59	158.59	55.09	13.14	10.97	251.68	17.41	42.67	3086	6707	31.50
N_3: 120 kg N ha^{-1}	208.13	170.15	58.55	14.02	11.89	275.85	18.52	49.43	3463	7438	31.91
S.Em±	5.97	4.42	1.54	0.38	0.35	6.79	0.23	1.36	83	268	0.53
CD at 5%	17.43	12.91	4.51	1.11	1.01	19.83	0.67	3.97	243	781	NS
Time of N application (T)											
T_1: Two equal splits (at sowing and 30 DAS)	184.28	150.67	52.86	12.15	10.38	237.02	15.52	38.75	2731	6104	31.14
T_2: Three equal splits (at sowing, 30 DAS and 45 DAS)	190.13	159.39	58.44	13.49	11.11	254.64	16.91	44.51	2988	6552	31.32
T_3: Four equal splits (at sowing, 30 DAS, 45 DAS and 60 DAS)	206.92	167.49	54.65	13.81	11.68	271.16	17.92	47.48	3331	7171	31.54
S.Em±	5.97	4.42	1.54	0.38	0.35	6.79	0.23	1.36	83	268	0.53
CD at 5%	17.43	12.91	4.51	1.11	1.01	19.83	0.67	3.97	243	781	NS
Interaction (N x T)											
S.Em±	10.34	7.66	2.67	0.66	0.60	11.77	0.40	2.35	144	464	0.92
CD at 5%	NS	NS	NS	NS	NS	NS	NS	6.87	421	NS	NS
CV %	10.68	9.63	9.67	9.98	10.83	9.25	4.73	10.80	9.55	14.03	5.87

Table 2: Interaction effect of rate and time of N application on grain weight per cob and grain yield (kg ha^{-1}) of summer maize

Rate of Nitrogen (N)	Grain weight per cob (g)				Rate of Nitrogen (N)	Grain yield (kg ha^{-1})			
	Time of N application (T)					Time of N application (T)			
	T_1	T_2	T_3	Mean		T_1	T_2	T_3	Mean
N_1	37.79	38.37	39.80	38.65	N_1	2385	2480	2637	2501

N_2	38.63	42.19	47.18	42.67	N_2	2808	3177	3273	3086
N_3	39.84	52.98	55.48	49.43	N_3	2999	3307	4084	3463
Mean	38.75	44.51	47.48		Mean	2731	2988	3331	
	Rate of N	Time of N	N x T			Rate of N	Time of N	N x T	
S.Em±	1.36	1.36	2.35		S.Em±	83	83	144	
CD at 5%	3.97	3.97	6.87		CD at 5%	243	243	421	
CV %	10.80				CV %	9.55			

Table 3: Effect of rate and time of N application on cost of cultivation, gross realization, net realization and B:C ratio of summer maize

Treatment	Yield (kg ha^{-1})		Total cost (₹ ha^{-1})	Gross realization (₹ ha^{-1})	Net realization (₹ ha^{-1})	B:C ratio
	Grain yield	Straw yield				
Rate of N application (N)						
N_1: 60 kg N ha^{-1}	2501	5682	25428	60243	34815	1.37
N_2: 90 kg N ha^{-1}	3086	6707	25799	73118	47319	1.83
N_3: 120 kg N ha^{-1}	3463	7438	26164	81697	55533	2.12
Time of N application (T)						
T_1: Two equal splits (at sowing and 30 DAS)	2731	6104	25441	65381	39940	1.57
T_2: Three equal splits (at sowing, 30 DAS and 45 DAS)	2988	6552	25797	71028	45231	1.75
T_3: Four equal splits (at sowing, 30 DAS, 45 DAS and 60 DAS)	3331	7171	26153	78649	52496	2.01

Conclusions

The findings of the experimentation indicated that application of 120 kg N ha^{-1} in four equal splits at sowing, 30 DAS, 45 DAS and 60 DAS discernibly improved plant growth, yield attributes and yield of summer maize (GM-6). The net realization was also higher for the above treatment combination as compared to rest of the treatment combinations.

References

1. Andrea KED, Otegui ME, Cirilo AG, Eyherabide G. Genotypic variability in morphological and physiological traits among maize inbred lines. *Crop Science*, 2006;46:1266-1276.
2. Anonymous. Area, production and productivity of maize in world. United States Department of Agriculture 2016.
3. Gehl RJ, Schmidt JP, Maddux MD, Gordon WB. Corn yield response to nitrogen rate grown under Bursa conditions. Turkish Journal of Agriculture and Forestry, 2005;24:341-347.
4. Hammad HM, Ahmad A, Farhad W, Abbas F, Qasim K, Saeed S. Nitrogen stimulates phenological traits, growth and growing degree days of maize. Pakistan Journal of Agricultural Sciences 2013;50(3):337-344.
5. Li H, Liang Li T, Wegenastb CF, Longinb X, Xua AE, Melchingerb S et al. Effect of N supply on stalk quality in maize hybrids. Field Crops Research, 2010;118:208-214.
6. Niaz A, Yaseen M, Arshad M, Ahmad R. Variable nitrogen rates and timing effect on yield, nitrogen uptake and economic feasibility of maize production. Journal of Agricultural Research 2014;52(1): 77-89.
7. Rahman MM, Paul SK, Rahman MM. Effects of spacing and nitrogen levels on yield and yield contributing characters of maize. Journal of the Bangladesh Agricultural University, 2016;14(1):43-48.
8. Rizwan M, Maqsood M, Rafiq M, Saeed M, Zahid A. Maize (*Zea mays* L.) response to split application of nitrogen. International Journal of Agriculture and Biology 2003;5(1):19-21.
9. Shah Z, Shah SH, Peoples MB, Schwenke GD, Herriedge DF. Crop residue and fertilizer N effects on nitrogen fixation and yields of legume-cereal rotations and soil organic fertility. Field Crops Research, 2003;83:1-11.
10. Sharifi RS, Namvar A. Effects of time and rate of nitrogen application on phenology and some agronomical traits of maize (*Zea mays* L.). *Biologija*, 2016;62(1):35-45.
11. Sharma R, Choudhary R, Jat BL. Effect of nitrogen and zinc fertilization on growth and productivity of maize. International Journal of Agricultural Sciences, 2017;13(2):161-176.